AN INTERACTIVE GRAPHICS APPROACH TO THE
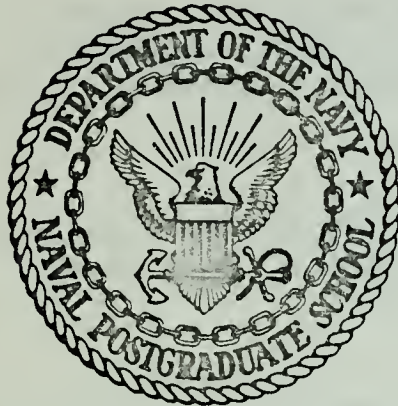## FLIGHT DECK HANDLING PROBLEM

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THESIS

AN INTERACTIVE GRAPHICS APPROACH TO THE

FLIGHT DECK HANDLING PROBLEM

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ABSTRACT

Present communication networks aboard aircraft carriers intro-
duce inefficiency into the aircraft handling operation. A previous study,
named CADOCS, failed to solve the problem by a method involving
computer simulation. This study proposes a solution to the aircraft
handling problem by use of a system of computer graphics terminals
and interactive or "man-in-the-loop" programming. The study includes
a proposed communication network, a discussion of the types of com-
puter graphics hardware now available, a discussion of interactive
programming, and a preliminary computer graphics program for two
displays in the proposed system.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

We are all somewhat familiar with the romantic beginnings of Naval Aviation, and its progress from the primitive Langley to the viable fighting force that it proved to be in World War II. In those days of propeller aircraft the operational doctrine employed by the carriers was to fuel and arm the bulk of the aircraft aboard, perform the mission, return to the carrier, and repeat the process. No closed time cycle system was required. This doctrine continued into the Korean War. It was in the midst of this conflict that the jet made its debut as a carrier aircraft, and caused a dramatic change in the operating procedure.

Whereas propeller aircraft could loiter for extended periods, the higher rate of fuel consumption of a jet aircraft demands that a much higher flight deck availability be provided upon its return from a mission. Hence the introduction of the cycle -- a smaller number of aircraft would be launched and, while they were performing their mission, the remainder of the attack force would be replenished. Then these aircraft could be launched to free the flight deck for the returning aircraft from the first launch.

While this solution greatly eased the short endurance problem of the jet, it also greatly compounded the problems of the evolution known

as the "respot." Without experience aboard an operating carrier it is difficult to imagine the complexity of the aircraft respot operation. It is best illustrated by observing the sequence of events as a returning aircraft recovers on the flight deck. After clearing the arresting gear the pilot usually taxis the aircraft forward, where it is chained down. Re-fueling and general servicing of the aircraft begin immediately, even before the rest of the returning aircraft land. Upon recovery of all returning aircraft, those that were chained down forward are towed aft to clear the catapults for the upcoming launch. After being chained down again, fueling and servicing is completed on those aircraft which still require it. Concurrently with these events, weapons are broken out from below decks and loaded onto the aircraft. Aircraft with maintenance problems deemed too serious or time consuming to be ready for the next launch are either stashed out of the way on the flight deck or snaked through the changing pattern of tightly packed aircraft to an elevator so that they may be transported to the hanger deck. Twenty to thirty minutes prior to launch, pilots and crewmen stream onto the flight deck to pre-flight and man their aircraft. About ten minutes before launch, ground support equipment (GSE) swarm around the aircraft to provide the compressed air to start the jet engines. Aircraft are then unchained again and taxied in an orderly manner along predetermined routes to the various catapults where they await their turn for launch.

Besides the confusion generated by the large number of men and various types of equipment needed for the above evolution, the problem is further complicated by constraints such as maneuvering restrictions on elevator use, availability and distance limitations of aircraft electrical sources and fuel lines, special position considerations for weapons loading and maintenance, and the need for rapid re-planning to accommodate unexpected mission changes and emergency situations.

The burden of most of the movement planning of aircraft for a particular spotting arrangement falls on the Aircraft Handling Officer (ACHO). His decisions are based on data collected via sound powered phones, ships telephone circuits, and messenger. The information is displayed by and on status boards and a scaled, two-dimensional model of the flight and hanger decks upon which are placed templates of specific aircraft in their relative positions. It is somewhat strange that such outdated methods are employed in this very critical phase of carrier operation; for the whole efficiency of the carrier hinges on its ability to expeditiously and safely recover, re-arm, re-fuel, and launch its aircraft. The lack of improvement in this area is even more unbelievable when it is compared to the major revisions and improvements which have been made in other systems such as Damage Control Central, Combat Information Center, NTDS, and Carrier Air Tactical Control Center.

In the mid 1960's work was begun to ease this problem with a project called Carrier Aircraft Deck Operations Control System

(CADOCS). This project's basic philosophy was that, since the aircraft handling problem was of cyclic nature, it was readily adaptable to simulation on a digital computer. By utilization of the computer's organizational ability and efficiency it was intended that the planning phase of flight deck handling would be both improved and accomplished in less time. Data were to be input from various control stations, and the computer's recommendations were to be displayed via the cathode ray tube (CRT) of a Computer Graphics system. Unfortunately, a suitable computer simulation of the respot evolution has yet to be developed, and in this author's opinion is infeasible for reasons discussed in a later chapter. Nonetheless, there are aspects of the CADOCS system which have much merit and can increase the efficiency of aircraft handling, supply, maintenance, and weapons loading.

It is the purpose of this study to combine useful parts of the CADOCS project and other recent studies on flight deck communication networks into a system using computer graphics as an interactive, rather than decision-making, system.

B. CRITIQUE OF CADOCS SYSTEM

1. Discussion

In 1966 a report entitled, An Exploratory Study of an Automated Carrier Aircraft Deck Operation Control System (NAEL-ENG-7375) outlined a possible solution to the problem of aircraft handling on the flight deck. The basic premise of the report was that many of

the deck handling decisions made on a carrier are of a simple, repetitive type, and are thus adaptable to computerization.

The report attacked both the software and hardware aspects of this problem. In software it tested a simple program designed to solve uncomplicated aircraft deck movement problems. The report described some success in the computerization of simple problems, concluded the method was feasible, and recommended further software development for more realistic problems. In hardware the report saw the need for a large computer controlled display board for location in flight deck control. In addition the report very correctly stated that no computer is any better than the information it receives. Thus it recommended a combination of fixed station and hand held digitalized devices to be used by flight deck personnel as a means of direct input to the computer.

In April 1967, a follow-up report entitled, Systems Definition Study of Carrier Aircraft Deck Operations Control System (NAEL-ENG-7453) was completed. This report furthered the philosophy that the solution of the aircraft handling problem lay in the overall computerization of the entire system. Towards this end it advocated reorganization of the present operational system into the concept of the totally integrated control system which consists of six functionally distinct, but interdependent, operationally oriented subsystems. These are the:

1. Primary Flight,

2. Retrieval,

3. Movement and Locator,

4. Service and Maintenance,

5. Weapon, and

6. Launching Control Subsystems.

In addition there is an Information Control Subsystem to provide computerized facilities for the support of all mission-oriented operational subsystems. Within each subsystem there exists a decision tree which defines the "up" or "down" status of the aircraft. Until an aircraft satisfies the criteria of each appropriate node of the decision tree within a subsystem, it is not passed to the next subsystem.

The underlying purpose of the decision tree in each subsystem is to provide a way for the master program in charge of aircraft handling to ascertain the current disposition of each aircraft to facilitate planning of the most efficient means of processing all aircraft from retrieval to launch. In order for a computer to plan effectively the respotting evolution, to sequence aircraft movement, to define the flow path of each aircraft, and to determine an optimal final spot to the degree that has been suggested by the CADOCS project, it is necessary to have a computer program which can in fact deal with the complex problems of actual operations with all the attendant, unpredictable variables. The ability to simulate an extremely simplified model

of aircraft handling in a computer, as was done in the CADOCS report, does not justify the idea that, by extrapolation, very complex models can also be solved.

Another problem in an overall computer solution is that since the computer is very much "on its own, " the aircraft position input data must be very accurate if effective solutions are to be achieved. In the spotting problem this is a difficult condition to meet; indeed, without a fairly fine grid layout on the flight deck or a closely defined set of parking spots (which would greatly restrict the versatility of spotting options), the computer would be incapable of formulating satisfactory spotting plans. Even if an accurate fine mesh grid could be laid on the flight deck (and this is doubtful), to prevent collisions the computer would have to maintain a certain buffer zone around each aircraft which would undoubtedly lead to inefficient spotting methods.

2. Favorable Aspects of CADOCS

1. The study has focused attention on an area of carrier operation that is in need of improvement.

2. CADOCS has shown that a more accurate means of relaying aircraft status and position data to decision makers is needed.

3. The study has shown that the status boards presently used are outdated, and a better display system is needed.

4. In compilation of data from various carriers for the study, a great disparity in standardization of operating procedures among different ships was discovered.

3. Unfavorable Aspects of CADOCS

    1. The seven subsystems proposed require massive re-structuring of the flight deck handling decision process. Even if this reorganization could be implemented, there is another implication which would make the change undesirable -- namely, if the system should fail, men would be forced to operate in a system designed and optimized for computer convenience.

    2. The inaccuracy of position data which would be fed into the computer could generate unrealistic solutions.

    3. Present day computers perform poorly in making subtle choices between very similar alternatives.

II. COMPUTER GRAPHICS

A. BASIC PRINCIPLES

As was briefly discussed in the previous chapter, an overall computer solution of the aircraft handling problem is presently impractical. An alternative to the computer solution, an interactive or computer-aided solution, is both preferable and achievable. This chapter discusses some basic principles and demonstrates a feasible way to achieve computer interaction.

When we use the term "interaction," there is not only an implication of communication between intelligent entities but also a flavor of communication with facility. With this in mind, the usual methods of communicating with a computer (by means of punched cards and printed output) hardly fulfill the concept of interaction. Computer scientists have been aware of this shortcoming for some time and with the development of third generation computers, the micro-computer, and with the recent rapidly increasing technology in computer controlled CRT's, feasible "interactive" systems have become possible.

There are many ways to achieve a computer initiated display, but each technique is a variation of the following description. All depend upon the cathode ray tube (CRT), in which a stream of electrons is passed between electrically charged plates to be focused on

an electron sensitive phosphorus screen. One pair of charged plates controls the vertical (y) deflection of the beam and the other pair controls the horizontal (x) deflection. (See Figure 1.) In operation, a control word is sent from the Central Processor Memory to the CRT Display Controller via a refresh buffer. (This buffer allows the terminal to frequently refresh or retrace the picture sent from the main computer and prevents the presentation from fading.) The CRT Display Controller uses information contained in the control word to determine which x and y signals to send to the deflection plates and whether to turn on the electron beam while the x-y signal is applied to the plates. If the beam is turned on, changing the x-y signal to the deflection plates causes a line to be drawn on the screen by the electron beam sweeping to its new x-y coordinates. A picture can be created by using several data words to define the x-y coordinates of the line segments to be drawn. Through the use of special circuits, called character generators, alphanumeric characters are also easily drawn.

As was mentioned above, it is necessary to refresh the presentation on the CRT to prevent display fading. If the display is not refreshed often enough (at least 40 times a second) the eye can discern the undesirable phenomenon called "flicker", which is observable brightening and fading of the display. Besides the elimination of flicker, the refresh process can be utilized to allow a user to designate a group of

text or a particular graphics figure on the CRT by simply touching a photo-sensitive wand or lightpen to the region of the CRT where the material to be selected is displayed. This is achieved by sending an interrupt to the computer when the lightpen senses the electron beam retracing the text to which it is pointing. Since the computer "knows" which group of text it was retracing when interrupted, it "knows" which group of text the user wished to designate.

When very large amounts of text or graphics figures are drawn, the electron beam can no longer retrace the display quickly enough to prevent flicker. If, however, the particular application of the CRT requires large amounts of text to be displayed, a flicker-free display called the storage tube may be advantageous. With the storage tube display, text and graphics figures are placed on the CRT screen with an electron beam in a manner similar to a refresh-type tube, but the screen is designed to hold the pattern without a refresh requirement. Since there is no retrace of the screen for the lightpen to sense, the lightpen option is not available with a storage tube.

B.   INTERACTIVE PROGRAMMING

The rapid input and retrieval capability of a computer graphics system make it possible to accrue enormous amounts of current information in the computer's data bank. It is not difficult to imagine how an overabundance of data can confuse more than help a decision

making process. For this reason, it is necessary to use modern methods of interactive or "man-in-the-loop" programming to aid the decision process.

It is necessary here to clearly define the notions of computer solution and computer interaction. In a computer solution, data are fed into the computer in a manner analogous to the way sensory perceptions are fed into the human brain. The computer then "decides" or provides a solution to a problem according to the algorithm, or recipe, which was programmed into it. Thus in the case of the spotting problem on the flight deck, for an overall computer solution the entire operation must be verbalized within the computer; and additionally all of the possible correct alternatives for any existing situation must be pre-programmed into the system. In the case where more than one alternative exists, each alternative must be "weighted" in light of the overall situation, to enable the computer to make a selection.

In a computer interactive system, data are also fed into the computer; but when alternatives exist, the computer presents the alternatives to the human, together with the data needed to make the decision, and lets the human make the selection.

A key technique of effective interactive programming is a method called programming by anticipation. By this method the desires of a user are anticipated and choices are presented which include all

possibilities. This method allows the user to <u>select</u> a desired option rather than <u>specify</u> that option, thereby allowing, for example, a lightpen action rather than requiring entry of an alphabetic command.[1] But programming by anticipation achieves more than just simplification of command input. By carefully planning the options to be presented to the user, the very structure of the decision process is improved. Because his alternatives are constantly before him, the user will be better able to determine the best course of action in a high noise environment.

By use of the method of "programming by anticipation" a fairly high degree of interaction in non-abstract types of problems can be achieved. To illustrate anticipatory programming, consider the hypothetical case in which an aircraft on the flight deck requires maintenance on the hanger deck. A menu page could be displayed on a graphics terminal listing the general aircraft evolutions which would be encountered by a particular decision maker, in this case the ACHO. He could select the evolution involving transferral of aircraft from the flight deck to the hanger deck with a touch of a lightpen to the display. The terminal would then display the up-to-date status and availability of all equipment that would be directly involved with the evolution, and list all the alternatives available. When the ACHO has made his

[1]Smith, L. B., "Use of Interactive Graphics to Solve Numerical Problems," <u>Scientific Applications</u>, v. 13, p. 631, October 1970.

decision, he touches the lightpen to one of the anticipated decisions listed on the screen and the terminal takes the desired action. It might add the information to a spot sheet; or it might take no action at all if the ACHO determines that with the given availability, the aircraft should remain where it is until a later time. The point is that the computer is aiding the decision maker by helping him to remember what equipment is involved, and presenting alternatives that were carefully thought out beforehand. Additionally, once the decision is made the terminal passes the word to the involved stations, records the information in its data banks (in case the decision infringes on future evolutions), and takes care of the necessary paper work. Thus, with well thought out anticipatory programming, a decision can be made with a much broader base of information and in a much shorter time.

C. CURRENT AVAILABLE HARDWARE

Due to the recent expansion of computer graphics utilization by industry, there has been a proliferation of new equipment and available options. Some options are discussed below in terms of their usefulness in the flight deck handling problem.

1. Display Options

One of the problems encountered in past proposals for computerized displays for the ACHO was that the CRT's were too small to allow the aircraft representations to be large enough to overlay

information and still be in scale with the representation of the flight deck. There are at least two solutions now available -- the large screen projection display system and the LITHOCON silicon storage tube.

a. Large Screen Projection System

The large screen projection system uses the output of a small, high-resolution CRT (controlled by the computer) and optically projects and enlarges an image of the display to up to a five foot square size. A drawback of the system is that a throw distance of ten feet is required to project the image for a five foot square display. An additional three feet are required for the CRT and optical equipment; thus approximately 13 feet of space must be free either behind or in front of the screen. The space presently available in Flight Deck Control would probably not accommodate a system of this size; however, minor alterations are possible which could greatly reduce system size. The CRT and projection unit could be placed at ground level in an enclosure. The projection could then be turned by a mirror to a screen mounted horizontally (table-top fashion). The screen size would be somewhat less than five feet square; but a display of $2\frac{1}{2}$-3 feet square should be adequate for a suitable flight deck presentation.

b. LITHOCON Silicon Storage Tube

The LITHOCON silicon storage is part of a Princeton 801 intelligent terminal system. In this system, display information

is written on a target of the LITHOCON tube by an electron beam, and is stored there as a pattern of charges. A raster scan (the type of scan used in television) of a small square, or window, of the LITHOCON tube's target is then presented to the viewer on a full sized CRT. The viewer has an option to "zoom in" on the display (accomplished internally by decreasing the size of the window to be presented on the CRT) for up to a 16:1 magnification factor. The zoom control consists of a joystick for manual X-Y positioning of the image center, and a size control allowing area magnification of 4:1, 9:1, 16:1, and 4/3. Thus a picture of the carrier and aircraft could be input to the LITHOCON target and the operator could either view the entire picture or zoom in on any desired position.

2. Hard Copy Feature

There are special copiers available to reproduce hard copies of the CRT presentation. The operator simply presses a button and a hard copy is produced in approximately eight seconds. This application would allow the ACHO to set up a special deck arrangement on the display and then make hard copies of the presentation for the handlers to use in movement of the aircraft.

3. Interactive Hardware

The light pen is an excellent interactive tool for use with the CRT, but it is not available with a storage tube display. If a storage tube display is used, good interaction can be achieved by programming

function switches for option selection, by numbering options and using a keyboard input for their selection, and by selecting options via an electronic cursor positioned by a joystick or track ball.

4. Character Generators

Alphanumeric text may be created by several different types of inexpensive character generators. Although the techniques of character generation vary, their net effect is the same -- upon receipt of a coded instruction they generate the character specified. Since flight deck displays will involve figures representing aircraft, it would be advantageous to have a character generator for each type of aircraft outline desired, as well as for alphanumeric symbols. This would eliminate the need to store data for creation of the graphics blocks of each aircraft, and in addition would greatly reduce the number of bits that would have to be sent between terminals to convey aircraft positioning data.

5. Color CRT

While a CRT capable of displaying vectors and text in color would be very useful in the flight deck spotting application, it is doubtful that the added usefulness would justify the additional cost of the CRT (approximately four times the cost of a black-white presentation) and the increased complexity of the overall system.

6. Terminals

Recent developments in mini-computers have promoted a change in concept for the designs of computer systems from a central

22

unit with large memory resources controlling remote input/output devices to a system of linked, intelligent terminals capable of both storing and processing their own data. In this latter system there is usually a slightly superior master terminal which controls slave terminals, but the slave terminals have a stand-alone capability. Although intelligent terminals have incredible processing and programming options and sizable storage capability, their physical dimensions (including a CRT presentation) are comparable to a cabinet-model television.

Intelligent terminals are inexpensive and are equipped with hardware and interface options too numerous to list in this study. While some of these options are considered and recommended in this study, it is noteworthy to mention that suitable alternatives exist today and others are constantly being developed and manufactured.

D. COMMUNICATION NETWORKS

The implementation of a graphics information system would have some behavioral effects on the participants in the spotting evolution, therefore a consideration of the results of behavioral science studies of communication networks is appropriate.

1. Basic Networks

Communication networks refer to the arrangement of communication channels in an organization. Figure 2 shows three representations of communication networks. Each node represents a

person or station which may pass or receive information to or

from another connected station. Notice that the circle has no natural

leader and that each member has direct communication only with his

immediate neighbor. The wheel, on the other hand, automatically

defines a leader who has a direct information input from every node

in the organization. The wheel has a highly centralized structure,

and the person in the center is said to have a high centrality index.[2]

Many studies have been made not only of the wheel and circle,

but also of numerous other structures with varying degrees of central-

ization. Before applying the results of these studies it is necessary to

consider the type of information that is to be passed. Information is

categorized as simple or complex. Complex information implies a

sense of abstraction; whereas, simple information would be of a type

that is already understood by the members of the organization. Since

the information in flight deck evolutions would definitely be classified

as simple, results of the studies as they apply to the simple category

will be presented.

The results of the studies are remarkably in agreement:

that in the passage of simple information, the wheel (or most

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[2] Bavelas, Alex, "Communication Patterns in Task-Oriented
Groups," Journal of the Acoustical Society of America, v. 22,
p. 725-730, 1950.

centralized structure) is the fastest, most efficient, and least error prone of any of the structures. The drawback of a highly centralized structure was that it had an isolatory effect on the non-centralized members of the structure.[3]

Non-central members, who can only communicate with one or two elements of the organization, become mesmerized with their own functions and generally fail to view their duties as they relate to the entire operation. The immediate result of this narrow view of the operation is that the isolated members tend to make requests that seem reasonable to them but are, in fact, not compatible with the organization's capability. When these requests are rejected by the decision maker in the central position of the communication network, the isolated members feel even more estranged. Some additional consequences of isolating members in a network are:

1. Loss of system effectiveness due to time lost in the rejection of unreasonable requests.

2. Low morale of isolated members due to their decreased sense of belonging.

3. Inability of isolated members to make innovative suggestions due to their lack of system-wide information.

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[3]Applewhite, Philip B., Organizational Behavior, p. 101, Prentice Hall, 1965.

2. Computer Graphics Communication Network

The ideal network would be one that would allow peripheral members to operate in their domain of interest without excessive distraction, and yet give them a view of the overall operation of the organization. Conventional communication systems such as the telephone or teletype are too time consuming in information passage to relay significant amounts of data, and at best give only a piecemeal perspective of organizational activities.

A computer graphics system would give the capability for a highly centralized structure for information passage in that the system, in its central position, would have access to data from all the peripheral stations. But the computer graphics system would also be able to provide every peripheral station with the same organized data that the central member receives -- thus overcoming the isolatory drawback of the conventional centralized system. (Figure 2c illustrates the effective communication capabilities of a computer graphics system.) Since a computer graphics system allows data to be presented in either a text or pictorial format, a well designed set of displays can provide the peripheral members with the high-quality information that will make them more effective in their particular tasks.

III. PROPOSED COMMUNICATION SYSTEM

A. DISCUSSION

As a preliminary communication system concerned only with the handling problem, graphics terminals would be located in the key decision area and at periphery points where there is special need of input and retrieval of information. Special note should be taken that with modern off-the-shelf intelligent terminals no central processor will be required; rather both processing and storage of data will be performed at each terminal.

Proposed locations for graphics terminals are:

1. Flight Deck Control

2. Primary Flight Control

3. Hanger Deck Control

4. Squadron Maintenance Offices.

(Additionally, data will be input from the flight deck as discussed in Section B.5 of this chapter. Also see Figure 3.) Each location, with the exception of Flight Deck Control, will require one intelligent terminal with a CRT display. Since Flight Deck Control is the focal point for the major handling decisions, two terminals are recommended for this location to provide the ACHO and the AWMC the flexibility and independence required to input and retrieve data for their respective

duties. In each intelligent terminal, storage is set aside to hold several matrices which contain all the data pertaining to the handling evolution. Since each terminal contains its own processor, the raw data held in the matrices may be organized by the terminal and displayed on its CRT in a format which best suits the user of the terminal. As the user of a terminal inputs his requests, decisions, or corrections to his terminal, the appropriate matrices are changed; and the same changes are transmitted by data link circuits to the other terminals in order to update their data matrices. Thus the matrices in all the terminals are continually corrected to reflect inputs made throughout the system. Although storing duplicate data and requiring intelligent terminals at each station might seem an inefficient use of equipment, there are several advantages of this approach as opposed to the use of a central processor system. Principal differences of the two systems are:

1. With intelligent terminals more flexibility in display formats at each station is possible.

2. If a central processor were used to accumulate data from remote inputs, the central unit would have to format the information for each terminal and transmit the organized data, in addition to the display commands to each terminal, by a multiplexor or time sharing technique. This would result in less service to the

terminals and require an enormous increase in the
number of bits to be transmitted by the data link as a
result of the need to send the display instructions.

3. The program of a centralized system would be com-
plicated and would not lend itself to easy display format
changes.

4. If the intelligent terminals were linked together in a
non-series fashion (preferably by a central bus design),
failure of one terminal would minimally degrade the
system's effectiveness. In a centralized system, failure
of the central processing unit would incapacitate the
system.

B. INFORMATION REQUIREMENTS AT STATIONS

For this preliminary proposal for an information system, the
exact formats of the displays and the data required for all stations
were not studied. However, a display for the ACHO and a display for
squadron maintenance personnel were designed and programmed to
gain insight into storage requirements and general feasibility of the
system. (See Chapter IV and the Appendix for a detailed explanation
of these displays.) Combining the experience gained in designing
these displays with a knowledge of the handling evolution, it is anti-
cipated that the following types of information will be put in and
retrieved at specific locations.

1. Flight Deck Control

   a. ACHO

   In his role as decision maker, the ACHO will primarily use the system to survey the current situation of the handling evolution. He will have access to information pertaining to aircraft positions on the flight and hanger decks, current fuel states of aircraft, overall status of all aircraft, status of flight deck equipment, fuel stations, power cables, etc. The main system inputs of the ACHO would be the results of his spotting decisions, proposed spotting schemes, items requiring action, and other information resulting from his decisions. In addition he could use the system to output hard copies of any of the above items (including spot sheets).

   b. Airwing Maintenance Chief

   Since the AWMC's duties are closely tied to those of the ACHO, his terminal would be organized to give him much the same information as used by the ACHO. More emphasis, however, would be placed on displays optimally organized to show aircraft status. Besides a list showing status of all aircraft, lists could be displayed showing up-aircraft on the flight deck, up-aircraft on the hanger deck, aircraft preferred for flight on a particular event as specified by the squadrons, etc.

   Since the AWMC has more freedom of movement about the flight and hanger decks than the ACHO, he could input changes into the data matrices of the system as he observes discrepancies.

2. Primary Flight Control

Since Primary Flight Control affords the best view of the flight deck, an operator here would use a lightpen and graphics terminal to continuously update the actual positions of the aircraft on the flight deck. In addition, he could respond to interrogations on his CRT concerning confirmation of a particular aircraft's position on the flight deck.

3. Hanger Deck Control

The Hanger Deck Officer could use his terminal to gain an overall view of the handling situation. In particular, he would benefit by having timely information of planned aircraft movement to or from the hanger deck. Hanger deck personnel would be required to input aircraft positions on the hanger deck in the same manner as the Primary Flight Control observer.

4. Squadron Maintenance Office

The displays for the squadron maintenance terminals would be designed to aid squadron personnel in planning their own maintenance requirements and allow expeditious entry of squadron related information into the system. Information provided to the squadron should include specific position of all aircraft on the flight and hanger decks, fueling status of aircraft, position of aircraft in relation to functional power and SINS cables, spotting intentions of the ACHO, etc. Availability of this information should reduce unreasonable

31

requests to the handling organization from the squadron. For example, a squadron having a presentation of all the aircraft on the flight deck and hanger deck would "learn" when it is not reasonable to request service for an aircraft that is "blocked-in." Additionally, by observing the position of their aircraft in relation to functional power stations and other aircraft, squadron maintenance personnel would be better able to plan their own maintenance schedule.

Information that would be input into the system by the squadron to aid the ACHO would include: aircraft up/down status, the estimated time aircraft will be in an up status, aircraft that will be preferred for particular events, and special requests such as de-fueling, high-power engine tests, etc.

5. Data Input from Flight Deck

The justification of the proposed system, with regard to utility, hinges on the ability to input current information into the system quickly. This problem was addressed by the preliminary CADOCS study and the solution proposed was to have both fixed and portable input devices conveniently located to allow flight deck personnel to input specified information to the system. In context of the proposed graphics system, it is desirable to input data concerning aircraft fuel state, status of aircraft with regard to the next launch, and status of various power cables and fuel lines.

No additional personnel would be required to input these data into the system. The fuels Petty Officer presently interrogates the pilot of each returning aircraft to determine his fuel on board. This figure is then subtracted from the fuel state of the aircraft after re-fueling to determine how much to bill the squadron for fuel received. With the hypothetical portable device the Fuels Petty Officer could quickly achieve four services:

1. By entering the fuel state of the aircraft, the status displays and the fuel state overlaid on each aircraft of the flight deck display would be updated to reflect his input.

2. This amount of fuel would be retained by the computer so that billing could be done automatically after re-fueling is completed.

3. At the same time he could enter the up/down status of the aircraft with regard to the upcoming launch, as reported to him by the pilot or Squadron Maintenance Chief.

4. The various fuel and power cable stations could be numbered consecutively, allowing him to enter simply a number and an up/down code when information as to the status of this equipment is reported to him by other flight deck personnel.

This information would greatly assist the ACHO, who is planning the re-spot while the recovery is in progress.

C. HARDWARE REQUIREMENTS

1. Memory

In order to provide information to the various stations discussed in Section A of this chapter it is necessary to store certain data in matrices and pass it to involved terminals. In addition, a certain amount of memory is required by each terminal to organize and create the various displays to be presented on the CRT at each terminal. In the following sections is presented an estimate of memory required for storage and display of essential matrices for the proposed graphics system. The basis for the estimation is a graphics program that was written by the author as a preliminary display study for the flight deck handling problem. While extravagant use of core is not advocated, keep in mind that with present day technology core storage in intelligent terminals is no longer the severe constraint that it was in the past. (For purposes of the below discussion, "word" refers to a 16-bit computer word since this is the predominant word size used in graphics terminals.)

a. Aircraft Data Matrix

This matrix contains a column for each aircraft with data for the aircraft contained in the rows. For each aircraft the following data must be maintained:

1. Side number

2. Up/down status

3. Fuel state

4. The X-Y position on the graphics presentation

5. The angular orientation of the aircraft on the flight deck.

6. Remarks Code -- a two-digit code is used to cross-reference a table of remarks in the memory of each terminal. This will reduce the number of bits required to be passed between terminals to add a remark to the aircraft description.

7. Intensity of the aircraft display symbol on the CRT.

By using logical bit manipulation, these data can easily be represented by 144 bits or nine 16-bit words. (Besides reducing storage required, compression of data and subsequent use of logical bit manipulation reduces the number of bits to be transmitted between terminals. If a circuit were dedicated to the system of terminals, it is doubtful, with the speed of bit transmission now available, that this compression will be necessary.) If data are to be kept for 100 aircraft, only 900 words will be required.

b. Spot Sheet Matrix

This matrix will carry the results of the ACHO's spotting decisions. If he were allowed to select ten aircraft to travel up

or down any or all of the four elevators, in addition to 60 go-aircraft and 20 spare-aircraft, a 4 X 80 matrix would be required, or 320 words.

    c.   Power Cable Matrix

        This matrix carries data giving the Up/Down status of power and SINS cables. Using logical bit manipulation, ten words can carry status information for all cables.

    d.   Words Required for Display Format at Terminals

        In order to display an alphanumeric string on a CRT, at least one text block must be established. This text block consists of a couple of control words followed by the string to be displayed. If, for example, a string of 80 characters were to be displayed in a single text block and two control words were required for each text block, 42 words would be required to display this string with one text block. (There are two characters/word in a 16-bit word.) Since the displays involved in the spotting problem require for the most part very short strings of text, it would be wasteful to allocate 40 or 50 words to each text block. As most options to be displayed are within ten characters, a seven-word text block would be advantageous for most terminals. (An exception to this would be the terminal used by the AWMC, since the status information of most interest to him consists of lengthy text strings.) A given terminal must have enough memory available to store the basic data that it will display, with enough core left over to

accommodate the display requiring the most text blocks. The particular display on any terminal that requires the most text blocks will be called the critical display for that terminal.

The critical display for the ACHO's terminal is the presentation of the flight deck and aircraft. Four text blocks will be required for each aircraft in order to show side number, fuel state, squadron event preference, and aircraft outline (assuming a single character generator is used to display the aircraft outline.) Thus, 240 text blocks or 1680 words are required for this portion of the presentation. Supporting text for options and lists should take at most 1000 words for a total of 2680 words required for the display aspect of the ACHO's terminal.

For the AWMC the critical display will be status-of-all-aircraft display. If the text block length for this terminal is set at 26 words (allowing 48 characters/text block) and two columns of 40 lines (one text block/line) are displayed, then 80 text blocks or 2080 words will be required for the display aspect.

For the Primary Flight Control and Squadron displays the critical display will be the display of the flight deck and aircraft; however, the requirements will not be as high as for the ACHO's display. This reduction in word requirement is achieved by displaying only the aircraft side number on the aircraft outline on the flight deck. The reasons for this apparent degradation of information at the squadron and Primary Flight Control stations are:

1.   The operator at Primary Flight Control has no need of any information other than side number overlaid on each aircraft.

2.   The reason for integrating information on the aircraft outline on the ACHO's display was to enhance spotting decisions. The addition of fuel state and squadron event preference on the aircraft outline is of no benefit to squadron maintenance personnel who are chiefly concerned with position of their aircraft in terms of accessibility and proximity to operative power sources. (Squadron personnel can determine fuel state from the squadron status display.)

3.   Since a smaller CRT accompanies the squadron terminal, excessive information would clutter the screen.

Taking this reduction into account, only 1500 words will be required for the display aspect of the flight deck presentation at the squadron and Primary Flight Control levels.

Since the Hanger Deck Officer is faced with a decision process similar to the ACHO, the same general format display will be given him as the ACHO. Thus, his critical display will require 2380 words.

e.   Summary of Memory Requirements

The approximate total core required at a terminal is the sum of its matrix storage word-requirements critical display word-

requirements, and its program/subroutine requirements. On this basis the following estimates of core requirements at each terminal for the flight deck handling displays are made in terms of 16-bit words:

1. Flight Deck Control

   AWMC -   8000 words

   ACHO -   8000 words

2. Hanger Deck Control -   8000 words

3. Primary Flight Control -   4000 words

4. Squadron Maintenance -   4000 words

2. Data Transmission

a. Communication Circuits

A basic requirement for a system of intelligent terminals is communications circuitry to carry data transmissions among the various stations. Since intelligent terminals have off-the-shelf interface equipment which permit the use of commercial telephone circuitry for this purpose, an obvious candidate for interconnection aboard ship is the ship's telephone circuits.

A recent study of communications aboard several aircraft carriers[4] found existing maintenance communication circuits inadequate for even existing voice message traffic. The study made a recommendation for the addition of circuits compatible to a central control

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[4]Naval Air Systems Command, R21-040-II, Final Report: Carrier Aircraft Support Study/Cass), p. 8-9, Dec. 1971.

unit, keyboard unit, CRT unit, and a printer. If in fact the findings of this study represent the existing situation aboard aircraft carriers and if partial or full dedication of a few circuits to data transmission cannot be realized, then implementation of the proposed graphics system will depend on the addition of adequate circuitry.

b. Rates of Data Flow

Existing state-of-the-art intelligent terminals have interface equipment available, capable of data transmission and reception of up to 9600 baud (bits/second). In the proposed system the largest block of data that would have to be passed is the aircraft data matrix, which consists of 14,400 bits of information. Even if this entire matrix were to be sent (this would be required only at system initialization), only 1.5 seconds would be required for data transmission and acceptance. A lower rate of 4800 baud would be less demanding on circuit requirements and would only increase the time requirement to 3.0 seconds. Transmission times could be minimized by sending data out only when some type of update is made at a terminal, and then by sending only data that were affected by the update. If connecting circuitry were not continuously available between terminals, altered data could be held in a buffer until transmission was possible.

In summary, existing achievable data transmission rates are completely adequate for the amount of data passage required by the proposed system.

3. Terminals

The choice of a terminal for a particular station in the flight deck handling problem should be made by applying the following criteria:

1. Overall size of the terminal and associated equipment in relation to the compartment it must occupy.

2. Memory available for a unit meeting criteria 1.

3. Size of the required CRT presentation.

4. Data transmission rates available.

5. Available options such as lightpens, function switches, hard-copy capability, etc.

6. Cost of equipment.

Practically all state-of-the-art equipment is capable of meeting the memory and data transmission needs of the proposed system; therefore the following recommendations as to terminal type at a particular station are made with the remaining criteria as a basis. Costs cited are current gross preliminary estimates for non-militarized versions not including installation and required circuitry, and are cited only to provide a measure of the scope of the problem.

a. Flight Deck Control

In Flight Deck Control a display will be required for both the ACHO and the AWMC because of the volume of input required at this location. Due to the rapid interactive needs of the ACHO, his

display should have a lightpen capability, thus a refresh-type display (vice a storage tube display) would be required. In addition his display should be large enough to provide at least a two-thirds view of the flight deck with to-scale aircraft outlines of approximately 1 inches in length. To meet this requirement, a screen 18-19 inches wide would be adequate. (For a full flight deck presentation with 1 inch aircraft outlines, a 27-inch width screen would be required.) The most promising prospect for these requirements is the Large Screen Projected Display System made by General Dynamics, modified as suggested in Chapter II, Section 1a to meet space requirements. No cost figures are available at this time (because of the recommended modification); however, the commercial cost of the system is estimated to be less than $15K.

The AWMC will not require so large a display because he can easily consult the ACHO's display if he requires aircraft position information. His primary information needs will be status of airwing aircraft and flight deck' yellow gear', which would require the presentation of large amounts of text. Since flicker becomes a problem on a refresh-type display when large amounts of text are displayed, a storage-type display is recommended for the AWMC. (Since information to be input at the terminal of the AWMC does not require a high degree of interaction, keyboard input of data would be adequate; so loss of the lightpen option is not a prohibitive drawback.) The

Princeton 801 Terminal with a LITHOCON silicon tube described in Chapter II. C. would be suitable for this application. The unit has a maximum data transmission rate of 2400 baud; but since it will be directly connected to the master terminal of the ACHO, this would be no problem. The standard screen size for this unit is a 10" X 10" CRT; however, larger screens are both available and recommended. Present commercial cost of the unit is $8024 including the zoom feature and data transmission interface equipment.

A hard-copy capability is recommended for the ACHO's terminal in Flight Deck Control. This would allow the ACHO to arrange a proposed spotting plan for special evolutions on his display, and then output a hard copy of how he desired the flight deck to be organized (including even side numbers on the aircraft). Current prices for hard copiers producing copies in 8-18 seconds at five cents/ copy is about $4000.

Total cost of the civilian version of equipment in Flight Deck Control is estimated to be $27.5K.

b. Primary Flight Control

In Primary Flight Control the principal duty of the operator will be to input position of aircraft on the flight deck by arranging the aircraft outlines on his display to coincide with their actual position. Since this will require a high degree of interaction, a display with a lightpen capability is recommended. Since a

large-screen projected display system would be impractical at this station due to size constraints, it is recommended that a 17-inch width CRT be used with a programmed zoom feature and a programmed X-Y shift of the presentation. For the spotting problem, it will be necessary to depict only the flight deck and aircraft side numbers. General Dynamics manufactures a 21-inch CRT in a militarized version that would be suitable for this station at an estimated cost of $8K.

c. Hanger Deck Control

Since this study's attention was focused on the flight deck spotting problem, an in depth review considering all facets of hanger deck operation was not made. However, a knowledge of aircraft position and status on the hanger would greatly benefit both the ACHO and squadron maintenance personnel. A terminal similar to the one recommended for Primary Flight Control with 8K of memory should be adequate for this purpose in addition to providing the capability to handle other requirements of the Hanger Deck Officer.

d. Squadron Maintenance

Due to the ease of interaction which a lightpen affords a relatively untrained operator, a refresh-type display would be beneficial for the squadron station. However, since the rate of data input required at this station is relatively low, and present editing and input methods for storage tubes require little more skill than required for a standard typewriter, a terminal with a storage type

tube would also be adequate. This unit should be a single chassis design with a 17-inch diagonal CRT and would occupy little more space than a conventional teletype. For flight deck spotting considerations alone, hard-copy equipment is not recommended for the squadron level terminal; however, the terminal should have a hard-copy capability in case later expansion of the system dictates a need for the option. Estimated cost for each squadron (for civilian versions of either refresh or storage-type displays) is $8K.

    e.   Flight Deck

Critical information is entered into the system from the Flight Deck as discussed in Section A-6 of this chapter. There are three general types of input devices that could be used to enter this information:

    1.   A completely portable device.

    2.   A portable device requiring connection to fixed jacks located at the edges of the flight deck.

    3.   A fixed position device located at practical locations.

Of these three possibilities, the completely portable device provides by far the most expeditious means of data entry and is therefore highly recommended for development.

Figure 4 shows a suggested design for a portable input device with the following features:

1. For durability, numbers in the windows would be set by mechanical thumbwheels.

2. The data input would be partitioned and include two "send" buttons so that data pertaining to either aircraft or flight deck equipment could be sent independently.

3. An acknowledge light would be required to signal the user that data were accepted by the terminals.

4. The device would have an enable lock to prevent unauthorized personnel from entering spurious data.

5. Dials would be internally illuminated to facilitate night use.

6. The device would be operated in a frequency range to comply with EMCON standards.

IV. A GRAPHICS PROGRAM TO AID AIRCRAFT HANDLING

The previous chapter outlined a proposed graphics system and listed possible types of information to be inputted and retrieved from the various terminals. This chapter discusses the computer graphics displays of a program written by the author on a computer system described in Appendix A, and describes the use of the program in an actual flight deck situation. Some concepts from the CADOCS study and the Carrier Aircraft Support Study (CASS), Volume II, were adopted in the program.

A. DISPLAYS OF THE GRAPHICS PROGRAM

Two displays were designed -- one depicting the flight deck and aircraft (Figure 5) and the other showing a squadron status board (Figure 7). Specific actions of each option on the displays are described in Appendix B and Appendix C.

The information overlaid on each aircraft (described on Figure 6) is continually updated and positioned by the computer. The aircraft are easily moved about the deck on the display by selecting the "MOVE" option with the lightpen and then touching the aircraft to be moved. Then the aircraft will follow the lightpen anywhere on the screen. If the nose of the aircraft is touched with the lightpen, the aircraft may be rotated to any desired orientation.

The display for the squadron status information (Figure 7) allows squadron personnel to input predicted and actual maintenance status information of their aircraft and, in addition, make certain requests to the ACHO. The display is designed by anticipatory programming methods and requires only the lightpen for data input.

B. APPLICATION

While the program which was written would be useful for any aircraft handling situation, its real value is best demonstrated in the stress situations that frequently occur on an aircraft carrier. To illustrate the use of the system in a high stress situation, the following scenario is presented to exercise the designed system. Remember that although each user will have the particular display that is most useful to his needs, all displays are available to each user on his CRT.

For the purpose of illustration, suppose that a change in mission is initiated for Event 6 (launch 6) at the Flag level and relayed to the command structure. Once the strike plan has been determined, the ready rooms, Air Officer, and ACHO are notified over the 19 MC intercom.

The squadrons immediately begin to evaluate the changes necessary in aircraft assignment to best accomplish the revised mission and compromise where necessary to be prepared for subsequent

48

missions. Suppose a squadron is required to supply four aircraft,

and six aircraft are suitable for the revised mission. By checking

the CRT displays of the flight and hanger decks, squadron personnel

can determine which aircraft are fueled and most suitable, because

of proximity to operative power cables and/or location, for Event 6.

With a lightpen the squadron decision maker touches "CHANGE

STATUS' and an aircraft he nominates to go on Event 6, for example

aircraft 304. (See Figure 7.) The entire status line of 304 then

appears in the "change status" box ready for alteration. In Figure 6

the change to the remarks column has already been made.) Again

with the lightpen he touches the section of the change box which he

wishes to alter and then touches the words he wishes to be added;

in this case, "EVENT" and " *6* ". When his corrections on aircraft

304 are complete he touches "UPDATE" and the corrected version of

304 appears on the status list. Simultaneously on the flight deck dis-

play, aircraft 304 has a "6" added to show that the squadron would

prefer to have that aircraft go on Event 6.

At this same time all of the other squadrons are making their

preferences known in the same manner. After the preferences are

input, the ACHO can now make his spotting decisions by using the

display shown on Figure 5. Since aircraft fuel state, aircraft status,

and squadron preference are integrated with the actual position of

the aircraft on the flight deck, an optimal spotting plan is enhanced.

With a lightpen, the ACHO touches "GO A/C" and begins to touch

aircraft he wants to go on the Event 6 launch. (Of course, a provision

exists which allows him to correct mistakes easily.) As he touches

each aircraft, that aircraft "brightens up" on his display, to become

conspicuous, and thus help him evaluate the overall effect of his

decisions. Additionally, the aircraft he selects are listed under

"GO A/C" (or "SPARES," as appropriate). In a similar manner he

can designate required elevator traffic. Spot sheets could be made

directly from this information by use of a copier or line printer.

Once the ACHO has completed the spotting task on the display,

squadrons know exactly where to concentrate their plane captains to

move aircraft and where special maintenance effort is required, and

are able to make pilot assignments to specific aircraft. (Under the

present system, the unsafe condition exists that pilots often receive

aircraft assignments so late that they must make a hurried and there-

fore cursory examination of the aircraft's maintenance record.)

C. ADVANTAGE OF SYSTEM

The major operational advantages of the system, as illustrated

by the above example, are:

1. Information from many sources is quickly and accurately

    presented to the decision maker in a format that aids the

    decision process. This is in direct contrast to the present

method of operation where the ACHO must piece together
information from several sources and then perform in his
head the integration of fuel state, relative position of the
aircraft, status of the aircraft, proximity of aircraft to
operative power cables, and preference of squadron before
an intelligent decision can be made.

2. Since the computer instantly updates the displays, the
    decision maker can be reasonably assured that he has the
    most current information available.

3. Squadron personnel have the information available to
    evaluate their maintenance scheduling and aircraft flight
    requests within the scope of the entire flight deck and hanger
    deck operation. Additionally, everyone (with a CRT ter-
    minal available) is able to react immediately to the implica-
    tions of the ACHO's spotting decisions as displayed on the
    screen.

4. The application of the computer graphics system is not
    limited to the flight deck spotting evolution described above.
    Critical information from other subsystems such as weapons
    and supply could just as easily be put into the system with
    relevant data made available at interested stations.

5. The formats of the particular displays are easily alterable
    to effect more efficient performance as experience is gained
    with the system.

6. Unlike the CADOCS system, this system operates within

    the same organizational framework which is presently in

    use. Thus if one or several terminals should fail, personnel

    could fall back to methods that are currently practiced with-

    out calamitous effect. (Even with the failure of one or two

    terminals, those personnel affected would probably be close

    enough to an operative terminal to gain essential information.)

V. CONCLUDING REMARKS

A. SUMMARY

The main fault of the system proposed by the CADOCS study is that it attempted to achieve a closed-loop computer simulation of a problem that is best solved by a man-in-the-loop, or interactive system. In an interactive system the best traits of man and the computer are brought together -- namely, man's ability to choose between alternatives with subtle differences is combined with the computer's superior data storage and retrieval capabilities. Since the system proposed by this study is an interactive system, it could be easily assimilated into the existing organizational framework, requiring only minor changes to the present job structure of personnel. Thus in case of complete system failure, personnel could easily revert to present methods of operation to meet mission requirements.

An interactive graphics system presently provides the best vehicle to distribute information in an integrated format to all decision makers. Additionally, present state-of-the-art equipment is reliable, inexpensive, easy to operate, has a long service life, and would easily accommodate future growth of the system.

B. CONCLUSIONS AND RECOMMENDATIONS

1. An improved system of information dispersal would greatly improve the efficiency of flight deck handling operations.

2. A computer graphics man-in-the-loop system is the best approach for improving communication between the participants in the aircraft handling problem.

3. The feasibility of partial or full dedication of a few telephone circuits for use as a data link between intelligent graphics terminals should be studied. If use of these circuits is determined to be infeasible, then consideration should be given to the installation of special data link circuits as reocmmended by the Carrier Aircraft Suitability Study, Volume II, December 1971.

4. Types and locations of intelligent terminals should be in accordance with the proposed system described in Chapter III. The militarized versions of the terminals should have a specified reliability of at least six months.

5. Development and implementation of a hand-held, portable input device utilizing an EMCON-suitable radio transmitter for flight deck data input would be a key factor in system effectiveness.

6. To further justify implementation of the system, incorporation of Supply and AIMD into the system should be considered.

X-Y deflection signals

ON/OFF

CRT

CRT DISPLAY CONTROLLER

BUFFER REFRESH MEMORY

DISPLAY FILE (Control words)

Central Processor
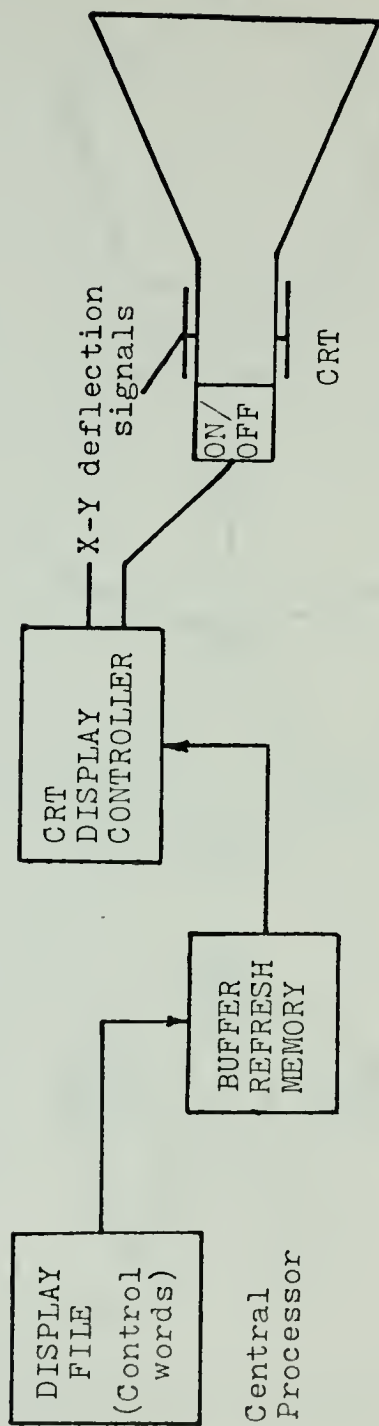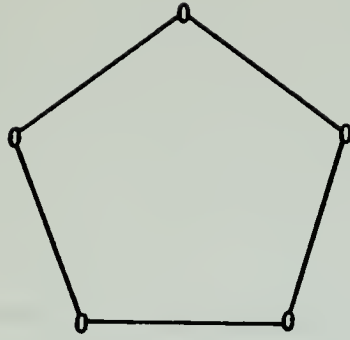
Figure 1

a) Circle
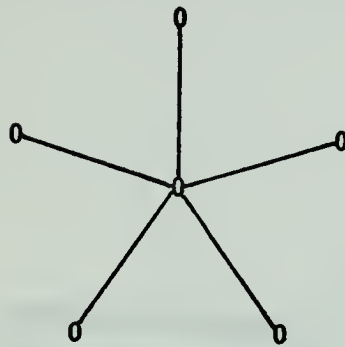
b) Wheel
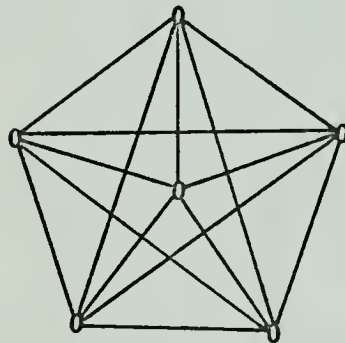
c) Computer Graphics System

(Lines do not represent actual circuitry;
rather they indicate capabilities of
inter-communication.)

Figure 2
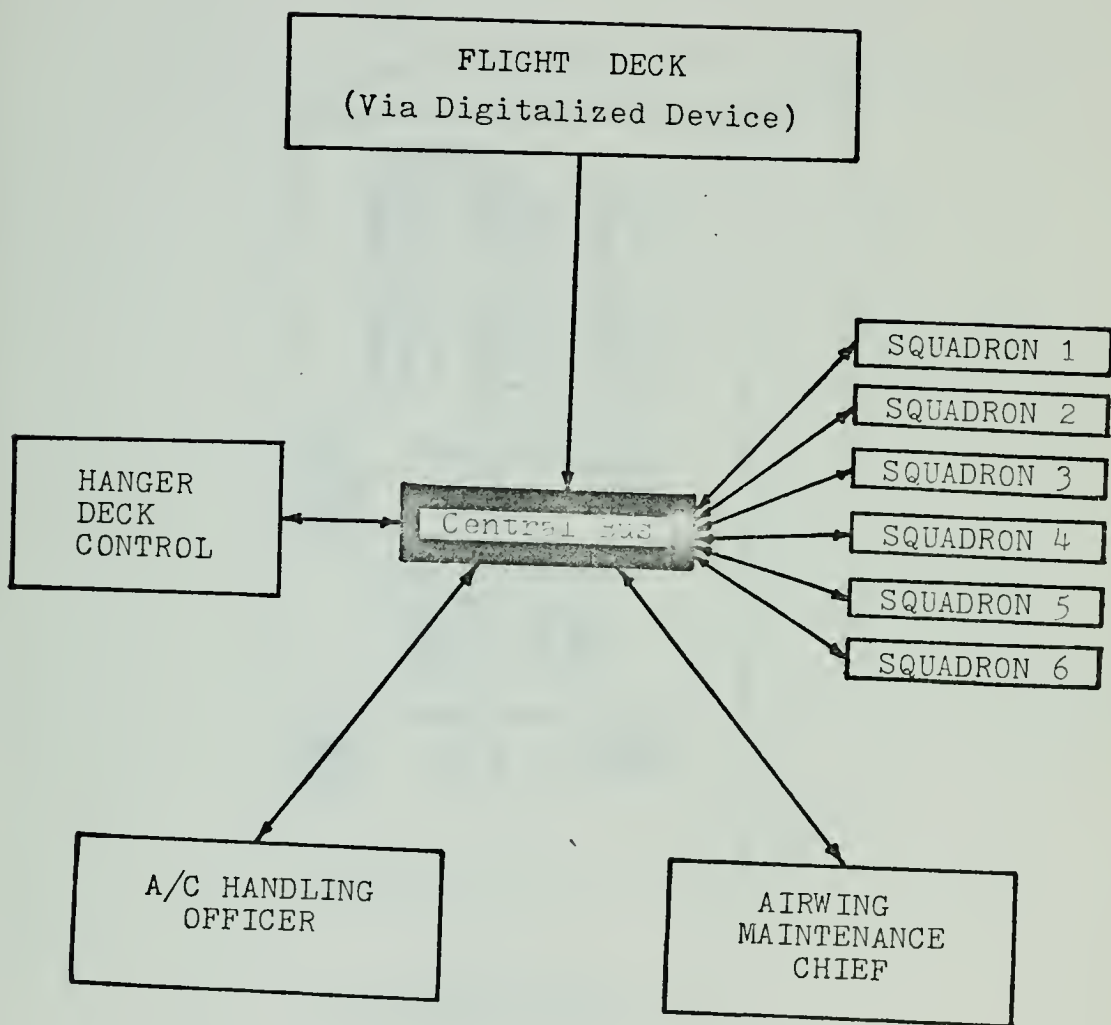
Figure 3
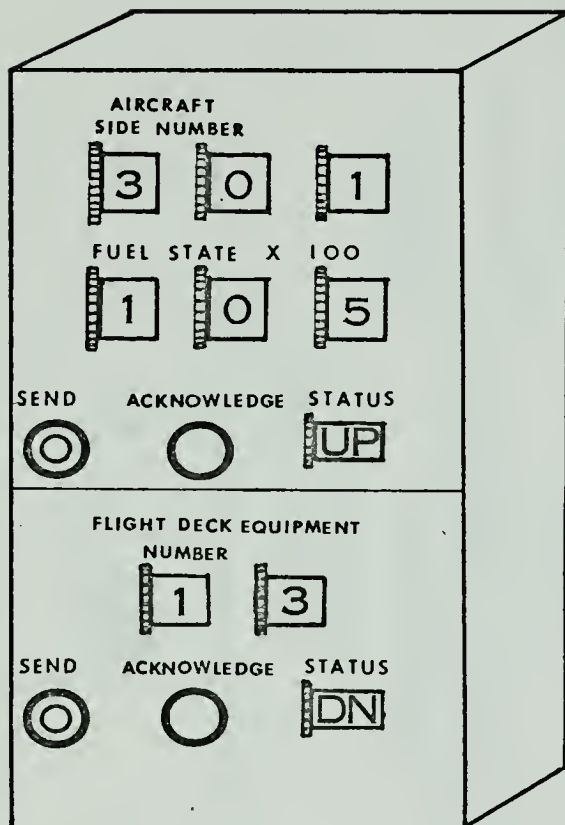
Suggested
Portable Flight Deck
Input Device

Figure 4

Figure 5

PC   S   S   S   PC   PC   PC

PC   S   S PC   PC   S

S   PC   PC$_S$ PC$_S$ PC$_S$

PC

1   *2*   *3*   *4*
101   *UP*{301   306

DOWN(9)
304

*A/C INFORMATION(6)
306 DN 170/1120 170/1430 F027 HYDRAULIC

STATUS DISPLAYS(7)   *AIRBORNE*(4)   *HANGER DK*(5)

ALL A/C   102   101
                       107   103
                       109   206
FUEL   200   209
                       203   301
YELLOW GEAR   207   306
                       210   308
CABLES   312
ELEVATORS

SQD STAT BRD(16)

(2)*MOVE*   *θ*(3)
(1)*ADD A/C*

STOP(12)

DELETE(13)

GO A/C(10)   *SPARE(11)
105   407   402
106   412   403
300
301
306
103

*SPOT PLAN
COMPLETE(14)

BLANK(15)

SIDE NUMBER OF
AIRCRAFT

1 O 2

F 1 5

PRESENT FUEL STATE
(#'s X 1000)

6

EVENT NUMBER
PREFERRED BY
SQUADRON

(Aircraft outline is dashed if its status
is down.)

Figure 6

(1)	(2)	(3)	(4)	(5)	(6)	(7)
A	300				F105	EVENT 7
A	301				F025	EVENT 6
H	302				F021	
H	303	DN	167/1300	NORS	F035	DE-FUEL
F	304				F105	
F	305				F105	
H	306	DN	170/1120	170/1430	F027	HYDRAULIC
H	307				F105	EVENT 6
F	308				F105	EVENT 6

(10) UPDATE   (7) CHANGE STATUS   (11) NO CHANGE   (12) FLT DK

CHANGE STATUS BOX(8)   (9)

304	**	**	**	**	F105	EVENT 6
1	*2*	*3*	*4*			NORS
	0					BEACH
5	*6*	*7*	*8*	*9*		

ELECTRICAL
ENGINE
HYDRAULIC
NAVIGATION
RADAR

EVENT
NO FUEL
DE-FUEL

Figure 7

APPENDIX A

COMPUTER PROGRAM INTRODUCTION

To illustrate the principles of interactive graphics displays as applied to the flight deck handling problem, a computer program was written to aid the decision making process of the ACHO. The equipment used was an XDS 9300 coupled with an Adage Graphics Terminal (AGT/10).

The XDS 9300 is a medium sized, general purpose digital computer system with 32K words of main core memory. The AGT/10 is a small general purpose digital computer with 8K words of main memory and a magnetic disk for secondary storage. After initial program load and data initialization, input to the system was via the AGT/10 Graphics Terminal with a lightpen, and output was visually displayed on the terminal screen.

The program logic was written in Fortran IV supplemented with a few special assembly language subroutines which built up the text blocks and graphics blocks for the buffers of the AGT/10. In order to understand how rapid interaction is achieved via the lightpen in the displays, it is necessary to discuss briefly two of these subroutines.

The first to be discussed is a subroutine called TEXTO. TEXTO allows the programmer to create one text block on the

graphics terminal starting at a vertical line position and a horizontal

character position which he specifies. Each time TEXTO is called

using a different line and character position, a new text block is

created with a reference number one higher than the previous text

block. A complimentary subroutine was written to allow the deter-

mination of the text block number of an alphanumeric string already

displayed on the Graphics Terminal simply by touching a lightpen to

the region on the screen where the alphanumeric string is displayed.

As an illustration of the use of these subroutines, consider this

example: Display a number of options to the user on the Graphics

Terminal at various line and character positions by calling TEXTO

for each option to be displayed. Each phrase, representing a user

option, will thus have a different text block number associated with

it. Suppose one of the options displayed is the word "FLIGHT DECK".

In order to select this option, the user simply touches the lightpen

to the phrase "FLIGHT DECK' and the integer value of the number

of the textblock corresponding to this phrase is returned to the master

program. This value is then used in a logical expression to branch

the program to an appropriate algorithm; in this case, to create a

display of the Flight Deck.

The second special subroutine is called GRAPHO. GRAPHO

is similar to TEXTO, except that it creates graphics blocks instead

of text blocks. In this application, the representations of the flight

deck and each individual aircraft were created by separate graphics blocks. Thus by touching the lightpen to an aircraft, the number of its graphics blocks is returned. In this program, a data matrix was set up with the graphics block number of the aircraft corresponding to the column in the matrix which contains data on the aircraft.

The program was written in a modular format, which uses a separate subroutine for each major option selected by the user with the light pen. Alteration of the job structure of a particular option is easily achieved by changing the appropriate subroutine.

A matrix was established which contains the data needed to establish the formal parameters of the subroutine TEXTO. Thus, by using a single TEXTO statement in a DO-loop which increments the rows of the parameter matrix, all of the master options and supporting text can easily be displayed. Besides preserving the correspondence of text block number to the option desired, the matrix also permits rapid alteration of the format of the text on the graphics terminal.

Appendix B and Appendix C describe the operation of the displays of this program.

DISPLAY OF ACHO

This appendix discusses the specific actions required to operate a program written to aid the spotting decisions of the Aircraft Handling Officer (ACHO). The program is controlled solely by use of a lightpen on a CRT display shown in Figure 5. The display was designed to both anticipate the informational needs of the ACHO and provide a means for him to record his decisions.

The display itself is a depiction of the flight deck showing the relative positions of aircraft. On the borders of the flight deck the letters "PC" and "S" are displayed to indicate the locations of power cables and SINS cables. These letters are normally dimly displayed on the CRT; however, if one of the cables is inoperative, the appropriate letter or letters are displayed brightly to alert personnel requiring use of the cable.

Below the flight deck are listed various phrases representing options which can be selected with a lightpen for the purpose of directing the computer to perform various tasks. Operation of the display is best explained by discussing what transpires upon selection of an option or sequence of options. (The numbers in parenthesis in Figure 5 are not actually on the CRT display but were added to aid the following discussion.)

ADD A/C (1)-- Selection of this option with the lightpen allows the user to add the outline of an aircraft to the flight deck by selecting its side number with the lightpen from the "AIRBORNE" or "HANGER DK" list. The outline will have the aircraft side number, current fuel state, and preferred event number superposed. To allow immediate positioning, the "MOVE" option will be automatically selected by the computer.

MOVE (2) -- This option enables an aircraft already displayed on the flight deck to be moved to a new location and/or be rotated to a new orientation. After selecting *MOVE* an aircraft must be designated by touching the lightpen to the outline of the aircraft to be moved. Upon touching an aircraft, cursors will be displayed on the center of the aircraft and forward of the nose of the aircraft. If the lightpen is placed on the center cursors, the aircraft will follow the lightpen anywhere on the display. If the lightpen is placed on the forward cursors, the aircraft will rotate on its turning axis in the direction the lightpen is moved. When the aircraft is in the desired position, the lightpen is touched to a dot located between the center and forward cursors, and a new aircraft may be designated for movement. When all desired aircraft position changes have been made, selection of the *θ* (3) causes the "MOVE" option to be terminated.

θ (3)-- Selection of this symbol causes the computer to exit from the "MOVE" mode.

AIRBORNE (4) or *HANGER DK* (5) -- Selection of one of these options and an aircraft on the flight deck results in the removal of both the outline and associated text of the aircraft from the flight deck. The aircraft side number is then inserted by the computer into either the airborne or hanger deck list, as appropriate, in ascending numberical order to provide the ACHO a quick reference of the general positions of all the aircraft.

A/C INFORMATION (6) -- Selection of this option and an aircraft either on the flight deck or in the airborne/hanger deck lists, presents the ACHO with current status information of the selected aircraft. (The significance of the numbers in the status data is explained in Appendix C.)

STATUS DISPLAYS (7)-- Selection of one of the options listed under "STATUS DISPLAYS" will cause the CRT screen to blank momentarily and a status list of the equipment referred to by the option selected to appear on the screen. After obtaining the information desired, the ACHO selects "RETURN" on the status list; and the flight deck presentation will re-appear on the CRT.

The following options are related to creating a display of the spotting plan in the lower-right section of the CRT. As the ACHO creates the spotting plan display with the lightpen, the computer

fills a matrix with his inputs so that the information can be sent to the squadron terminals. "UP" (8) and "DOWN" (9) in the spotting sheet refer to the direction the elevator will carry the aircraft; and "1" "2", "3", "4" refer to the specific elevator which will transport the aircraft. "GO A/C" are the aircraft that will be on the next launch, and "SPARE" are the aircraft intended to replace any "GO A/C" that are disqualified for the next launch.

UP (8) or *DOWN* (9)-- Selection of one of these options and designation of an elevator number (*1*, *2*, *3*, or *4*) permits the ACHO to enter side numbers of aircraft on the flight deck or in the hanger deck list into a particular part of the spotting plan. For example, to designate aircraft 101 and 103 for movement up elevator one, the ACHO touches *UP* (8) and *1* with the lightpen and then touches 101 and 103 in the "HANGER DK" list. When all aircraft that are desired to be listed for travel on a particular elevator have been chosen, *STOP* (12) is designated. Now aircraft may be listed under a different elevator/direction if desired, or the same elevator/direction may be re-selected for further additions.

GO A/C (10) or *SPARE* (11)-- Selection of one of these options allows the ACHO to add side numbers of aircraft to the "GO A/C" or "SPARE" list by designating aircraft on the flight deck or in the hanger deck list. When the aircraft desired have been added, *STOP* (12) is selected.

STOP (12).. Selection of this option notifies the computer to discontinue (until further notice) adding aircraft to the list within the spotting plan which was currently being operated upon.

DELETE (13).. This option permits the ACHO to delete one aircraft from any list within the spotting plan by touching the lightpen to that aircraft. For each aircraft to be deleted, the option must be re-selected.

SPOT PLAN COMPLETE (14).. Selection of this option causes the word "COMPLETE" followed by an identification number to appear at the bottom of the spotting plan in order to signal squadron personnel that no further changes are made. If a change is subsequently necessary, the "COMPLETE" label disappears when one of the change options is selected; and a bell sounds at squadron terminals. When the ACHO makes the additional changes and re-selects *SPOT PLAN COMPLETE* (14), the word "COMPLETE" again appears at the bottom of the spotting plan, but the accompanying identification number is incremented by one to alert squadron maintenance personnel (who may have missed the bell signal) that there is a new spotting plan.

BLANK (15).. This option clears the spotting plan of all aircraft side numbers. Since accidental selection of this option could represent a significant loss of time to the ACHO, a safety factor is built into the option. If this option is selected, the word "*BLANK*" brightens and increases in size; and the computer delays

for two seconds. If, in fact, the ACHO did desire to blank the spot-

ting plan, he must select *BLANK* (15) again; otherwise, the display

is not affected.

SQUAD STAT BRD (16)-- This option is used in this pre-

liminary program to provide the user access to a display that would

be used on a squadron terminal. The use of the display is discussed

in Appendix C.

APPENDIX C

DISPLAY OF SQUADRON MAINTENANCE

This appendix discusses the specific actions required to operate a program written to aid squadron personnel in maintaining computer-held data concerning the status of their aircraft. Input to the computer is achieved solely through use of a graphics terminal and lightpen.

The upper half of the display lists the status of each of the squadron's aircraft according to the format shown in Figure 7. The lower half of the display provides squadron personnel the capability of altering the data in each status line. (The numbers in parenthesis in Figure 7 are for use in the following discussion and are not actually displayed on the CRT.)

Before explaining how data in each status line are altered an explanation of the data itself is necessary. (The numbers of the following list refer to the numbers in parenthesis on Figure 7.)

1. This field of the status line indicates the general location of the aircraft according to the following code --
   F, flight deck; H, hanger deck; and A, airborne. This information is automatically updated on the squadron display by inputs into the system from other terminals.

2. This field contains aircraft side number.

3. This field contains either "UP" or "DN" (down) and des-
    cribes the overall condition of the aircraft. If squadron
    personnel enter "DN" in this field, the aircraft will not
    be used for flight.

4. This field contains the Julian date and time the aircraft
    went into a down status.

5. This field contains the Julian date and time the squadron
    estimates the aircraft will be returned to an up status.
    If an estimated up-time cannot be given because the aircraft
    is ashore and not under squadron control, "BEACH' is
    listed in this field. If an estimated up-time cannot be given
    because parts to correct the downing discrepancy on the
    aircraft are not available, "NORS" (Not Operationally Ready,
    Supply) is listed in this field.

6. This field lists the current fuel state of the aircraft in
    hundreds of pounds and is normally updated via data link
    from the flight deck. However, if the squadron is aware
    of an error in the fuel state shown, they can update this
    field.

7. Remarks may be placed in this field by the squadron to
    identify the specific problems of the aircraft or to make
    requests to the ACHO.

In order to alter any part of the status line, the user selects the option "CHANGE STATUS' with the lightpen and then selects the status line to be changed by touching any part of the status line with the lightpen. The status line, as it appears in the list, is then duplicated by the computer in the "CHANGE STATUS BOX" (8) with asterisks appearing in the fields that contained blanks. The user can now make desired alterations of the status line in the "CHANGE STATUS BOX." Upon touching the text displayed (or asterisk if the field was blank in the status list) in the field to be changed, that field is selected for update and entries may be made into the field from the list of options below the "CHANGE BOX." If, for example, the Julian data/time, 168/1400, is desired in field (9) of aircraft 304, the procedure would be:

1. Touch the asterisks in field (9) with the lightpen. (The field will go blank to indicate it is ready to accept new information.)

2. Below the "CHANGE STATUS BOX" touch the lightpen successively to the symbols, *1*, *6*, *8*, *1*, *4*, *0*, and *0*. As each number is touched it will appear in the correct position of field (9). After field (9) is filled, another field may be selected, if desired, and its contents may be changed in a similar manner by utilizing the list of options below the "CHANGE BOX."

If it is desired to "blank" a field, touch the lightpen to the desired field; but instead of selecting an entry from below, either select another field for update or terminate the "CHANGE STATUS' mode by selecting "UPDATE" (10).

There are two ways to exit the "CHANGE STATUS" (7) mode:

1. Select "UPDATE" (10). This will cause the data in the "CHANGE STATUS BOX" (8) to replace the data of the appropriate aircraft in the status list above. (At the same time, this new data is sent by data link to update that aircraft's status on the other terminals.)

2. Select "NO CHANGE" (11). This will cause the "CHANGE STATUS BOX" to blank and will effect no change in the status list above.

The option labeled "FLT DK" (12) blanks the squadron status board display and gives the user the flight deck presentation used by the ACHO.

The chief advantages of the display described above were found to be:

1. Quick entry of data into the computer system.

2. The display allows easy correction of errors made by the operator.

3. The lack of keyboard entries facilitate use of the display by untrained operators.

APPENDIX D

GLOSSARY

ACHO   -   Aircraft Handling Officer

AIMD   -   Aircraft Intermediate Maintenance Department

AWMC   -   Airwing Maintenance Chief

BAUD   -   bits per second

CADOCS   -   Carrier Aircraft Deck Operations Control System

CASS   -   Carrier Aircraft Suitability Study

CRT   -   Cathode Ray Tube

NORS   -   Not Operationally Ready, Supply

SINS   -   Ships Inertial Navigation System

```
C*****************************************************************************
C*****************************************************************************
C***        AN INTERACTIVE GRAPHICS PROGRAM FOR THE FLIGHT DECK
C***        HANDLING PROBLEM. WRITTEN FOR AN SDS 9300, INTERFACED
C***        WITH AN ADAGE GRAHPICS TERMINAL. ADEPT MONITOR
C***        PROGRAM IS NAMED 'SPOT'. (ON FILE AT NAVAL
C***        POSTGRADUATE SCHOOL, MONTEREY,CA.) EXECUTE PROGRAM
C***        WITH SENSE SWITCH 2 'ON'.
C*****************************************************************************
C*****************************************************************************
C*****************************************************************************
C*****************************************************************************
      REAL AC1X(63),AC1Y(63),AC2X(85),AC2Y(85)
      REAL SX(47),SY(47),IFILL(55),IT(30,6),IFILL2(55),IT2(30,6)
      INTEGER IDATA(16,20),IMD(85),ACPAK1(64),ACPAK2(86),SMD(47),SHIP(48)
      INTEGER GDIR(31),IMD(85),ACPAK1(64),ACPAK2(86),ACPAK(86,20)
      INTEGER TDIR(100),DISPLA,IPLAN(15,4),ACPAK(86,20)
      INTEGER                UP(4),DN(4),GO,GOCOL,SPARE
      NAMELIST INTRO(20,23)
      DATA IFILL/55*0/ IDATA/320*0/ IT/180*0/
      DATA UP/4*1/ DN/4*6/ GO/11/ SPARE/11/ GOCOL/1/ IPLAN/60*0/
      DATA FACX/330/ FACY /330/DACX/.5/ DACY/.5/ DELX/.4/
      DATA IDEV/2/ FACT/1.1/ DELY/.4/ DELX/-.15/ FACTY/1.4/
      NAC=5; IB=0; ITAC=10
C
C READ DATA FOR BOTH DISPLAYS
C
      READ(5,99)         SX(I),SY(I),SMD(I),I=1,47
99    FORMAT(2F10.3,IL)9X,2F10.3,I1)
      READ(5,90)         ((IDATA(I,J),I=1,16),J=1,20)
90    FORMAT(13A4,3I4)
      READ(5,100)        (IFILL2(J),J=1,53)
100   FORMAT(20A4)
      READ(5,101)        ((IT2(I,J),J=1,6),I=1,25)
101   FORMAT(6I3,3X,6I3)
      READ(5,106)        (AC1X(J),AC1Y(J),J=2,32)
      READ(5,106)        (AC2X(J),AC2Y(J),J=2,43)
106   FORMAT(8F10.5)
      READ(5,91)         ((IT(I,J),J=1,6),I=1,30)
91    FORMAT(6I3,3X,6I3)
      READ(5,92)         (IFILL(I),I=1,55)
92    FORMAT(10(A4,1X))
C
C PROCESS DATA FOR FLT DECK DISPLAY
C
```

```
      DO 102 J=1,ITAC
      IDATA(1,J)=LIOR(LLS(IDATA(1,J),6),000000060B)
      IDATA(2,J)=LIOR(LLS(IDATA(2,J),6),000000060B)
102   CONTINUE
C
      DO 5 J=1,47
      SY(J)=FACTY*SY(J)
5     CONTINUE
      SHIP(1)=IHEAD(0,5)
      DO 2 J=1,47
      SHIP(J+1)=IPACK((SX(J)*FACT+DELX),(SY(J)*FACT+DELY),SMD(J))
2     CONTINUE
C
C
      AC1X(1)=AC1Y(1)=AC2X(1)=AC2Y(1)=0.0
      DO 107 J=1,31
      AC1X(32+J)=AC1X(33-J)
      AC1Y(32+J)=-AC1Y(33-J)
107   CONTINUE
      DO 207 J=1,42
      AC2Y(43+J)=-AC2Y(44-J)
      AC2X(43+J)=AC2X(44-J)
207   CONTINUE
      IMD(1)=IMD(2)=0
      DO 108 J=3,85
      IMD(J)=1
108   CONTINUE
      DO 109 J=1,63
      AC1X(J)=AC1X(J)/FACX+ DACX
      AC1Y(J)=AC1Y(J)/FACY + DACY
109   CONTINUE
      DO 209 J=1,85
      AC2X(J)=AC2X(J)/FACX + DACX
      AC2Y(J)=AC2Y(J)/FACY + DACY
209   CONTINUE
      ACPAK1(1)=IHEAD(0,4)
      DO 110 J=1,63
      ACPAK1(J+1)=IPACK(AC1X(J),AC1Y(J),IMD(J))
110   CONTINUE
      ACPAK2(1)=IHEAD(0,4)
      DO 210 J=1,85
      ACPAK2(J+1)=IPACK(AC2X(J),AC2Y(J),IMD(J))
210   CONTINUE
C
C     READ AND PROCESS INFORMATION FOR INTRODUCTION
C
      READ(5,6) ((INTRO(I,J),I=1,20),J=1,23)
```

```
6     FORMAT(20A4)
      INPUT(101)
      CALL DTINIT(ICEV,TDIR,100,IER)
      CALL DGINIT(IDEV,GDIR,31,IER)
      CALL TEXTO(IDEV,INTRO(1,1),3,39,39,2,2,IER)
      DO 17 J=1,11
      CALL TEXTO(IDEV,INTRO(1,J+3),12,(2*J+4),1,2,2,IER)
17    CONTINUE
8     NS=0
      CALL TSEL(IDEV,0,NS,IER)
      IF(NS.EQ.0)GO TO 7
7     IF(NS.NE.1)GO TO 8
      CALL DTINIT(IDEV,TDIR,100,IER)
      CALL TEXTO(IDEV,INTRO(1,2),2,35,5,2,2,IER)
      CALL TEXTO(IDEV,INTRO(1,3),4,35,25,2,2,IER)
      DO 14 J=1,9
      CALL TEXTO(IDEV,INTRO(1,J+14),12,(2*J+4),1,2,2,IER)
14    CONTINUE
      KK=200000;CALL DELAY
9     NS=0
      CALL TSEL(IDEV,0,NS,IER)
10    IF(NS.EQ.0)GO TO 10
      DISPLA=3
      IF(NS.EQ.1)DISPLA =1
      IF(NS.EQ.2)DISPLAY =2
      GO TO (12,13,9)DISPLA

C
C     FLIGHT DECK DISPLAY
C
12    CALL DGINIT(ICEV,GDIR,31,IER)
      CALL FLTDK(IDEV,IDATA,ACPAK,GDIR,TDIR,ITAC,IT2,IFILL2,SHIP,NN,
     2IPLAN)
      NS=0
300   CALL TSEL(IDEV,0,NS,IER)
301   IF(NS.EQ.0)GO TO 301
      CALL TEXTI(IDEV,NN,1,0,NS,IER)
      IF(NN.EQ.4H*ADD)CALL ADDAC(IDEV,ITAC,IDATA,ACPAK1,ACPAK2,GDIR,
     2TDIR,IFILL2,IT2,SHIP,NN,IPLAN,ACPAK)

C     IF(NN.EQ.4H*MOV)CALL ACMOVE(IDEV,NS,IDATA,ACPAK,GDIR,TDIR,ITAC,IT2
     2 ,IFILL2,SHIP,NN,IPLAN)

C     IF((NN.EQ.4H*UP*).OR.(NN.EQ.4H*DOW).OR. NN.EQ.4H*GO ).OR.(NN.EQ.4H
     2*SPA)) CALL UDGS(IDEV,IDATA,UP,DN,GO,GOCOL,SPARE,NN,NS,IPLAN,
     3IFILL2,IT2,ITAC)
      IF(NN.EQ.4HA/C )CALL ACINFO(IDEV,ITAC,IDATA,NS,IFILL2,IT2)
```

```
C
      IF((NN.EQ.4HAIRB).OR.(NN.EQ.4HHANG))CALL AHLIST(IDEV,NN,IDATA,
     2 ACPAK,GDIR,TDIR,ITAC,IT2,IFILL2,SHIP,IPLAN,NS)
C
      IF(NN.EQ.4H*DEL)CALL DELETE(IDEV,IFILL2,IPLAN)
C
      IF(NN.EQ.4H*BLA)CALL BLANK(IDEV,NN,UP,DN,GO,GOCOL,SPARE,IDATA,
     2 ACPAK,GDIR,TDIR,ITAC,IT2,IFILL2,SHIP,IPLAN)
C
      IF(NN.EQ.4H*COM)CALL COMPLT(IDEV)
C
      IF(NN.EQ.4H*SQD)DISPLA=2
C
      GO TO (300,13)DISPLA
C
C     SQUADRON STATUS BOARD DISPLAY
C
   13 CALL DGINIT(IDEV,GDIR,31,IER)
      CALL DTINIT(IDEV,TDIR,100,IER)
C
C     CREATE SQD STATS BOARD
C
      DO 500 J=1,NAC
      CALL TEXTO(IDEV,IDATA(1,J+IB),13,(2*J-1),1,2,IDATA(14,J),IER)
  500 CONTINUE
C
C     TEXT CHOICES VIA IFILL AND IT
C
      DO 502 J=1,30
      CALL TEXTO(IDEV,IFILL(IT(J,1),IT(J,2),IT(J,3),IT(J,4),IT(J,5),
     2 IT(J,6),IER)
      IF(IER.NE.0) OUTPUT(102)'IER FROM IFILL =',IER
  502 CONTINUE
C
C     MAKE MASTER OPTION SHOICE
C
  501 IMCH = 0
      CALL TSEL(IDEV,0,IMCH,IER)
      IF(IMCH.EQ.0) GO TO 503
C
      IF(IMCH.EQ.(28+NAC)) CALL SQDUPD(IDEV,IDATA,IFILL,NAC,IB,IT)
C
      IF(IMCH.EQ.(26+NAC))DISPLA=1
C
   19 GC TO (12,501)DISPLA
      STOP
```

79

```
-FORTRAN LS.GO
      SUBROUTINE SQDUPD(IDEV,IDATA,IFILL,NAC,IB,IT)
      INTEGER IDATA(16,20),ROW(5),WRDS(5),CPOS(5),IPAD(16,IT)
      INTEGER MSK(3),MSK2(3),IBLNK(13),IT(30,6)
      DATA     ROW/ 2, 4, 6, 9,10/
      DATA     WRDS/ 2, 2, 3, 1, 4/
      DATA     CPOS/ 1,18,34,58,66/
      DATA     IBLNK/13*606060608/
      CALL TEXTO(IDEV,IFILL(46),4,26,13,1,3,IER)
      ID= 80000;  CALL DELAY
C
C       SELECT A/C FOR UPDATE
C
      JJ = 0
510   CALL TSEL(IDEV,0,JJ,IER)
      IF(JJ.EQ.0)GO TO 510
      IF(JJ.GT.NAC) GO TO 519
C   SET IPAD = A/C TO BE UPDATED
      DO 514 J=1,16
      IPAD(J) = IDATA(J,JJ+IB)
514   CONTINUE
C
C   PUT UP UPDATE FIELDS
C
      DO 511 J=1,5
      IF(IPAD(ROW(J)).EQ.4H     )IPAD(ROW(J)) = 605454608
      CALL TEXTO(IDEV,IPAD(ROW(J)),WRDS(J),29,CPOS(J),2,3,IER)
511   CONTINUE
C
C   PICK FIELD TO BE UPDATED
C
512   IFLD = 0
      CALL TSEL(IDEV,0,IFLD,IER)
513   IF(IFLD.EQ.0)GO TO 513
C   CHECK FOR "NO CHANGE"
      IF(IFLD.EQ.(NAC+29))GO TO 519
C   CHECK FOR "UPDATE"
      IF(IFLD.EQ.(NAC+25))GO TO 517
      IFLD = IFLD-NAC-30
      IF((IFLD.LT.1).OR.(IFLD.GT.5)) GO TO 512
C
C   BRANCH TO SECTION FOR CHANGING CHOSEN FIELD
C
C       FIELD =    1   2   3   4   5
```

80

```
         GO TO (560,550,540,530,520)IFLD
C
C  FIELD EQ 1    BLNK,DN,1-9
C
560   IPAD(3) = 60545460B
      CALL TEXTO(IDEV,IPAD(2),2,29,1,2,3,IER)
C
561   NS= 0
      CALL TSEL(IDEV,0,NS,IER)
562   IF(NS.EQ.0) GO TO 562
C
C  CHECK IF SELECTION IS SUITABLE FOR FIELD 1
      NS = NS-NAC
      IF(NS.GT.12) GO TO 512
      IF(NS.EQ.12) IPAD(3) = 4H DN
      IF(NS.LT.11) IPAD(3)=LIOR(60006060B,LLS(NS-1,12))
      CALL TEXTO(IDEV,IPAD(2),2,29,1,2,3,IER)
      GO TO 512
C
C  FIELD = 2
C
550   IPAD(4)=IPAD(5)=IFILL(11)
      CALL TEXTO(IDEV,IPAD(4),2,29,18,2,3,IER)
C
      IDIG = 3  ; MSK(3)= 00606060B; MSK(2)= 00006060B;MSK(1)=000000060B
      MSK2(3)= 77007777B; MSK2(2)=77770077B ;MSK2(1)=77777700B
      IPAD(4) = 000000000B ;IPAD(5)=000000000B
C
551   NS =0
      CALL TSEL(IDEV,0,NS,IER)
552   IF(NS.EQ.0) GO TO 552
C
C  CHECK IF SELECTION IS SUITABLE FOR FIELD 2
      NS = NS-NAC
      IF(NS.GT.10)IPAD(4)=IPAD(5)=60606060B; GO TO 512
      IPAD(4)=LIOR(IPAD(4),LIOR(MSK(IDIG),LLS(NS-1,6*IDIG)))
      CALL TEXTO(IDEV,IPAD(4),1,29,18,2,3,IER)
      IDIG = IDIG-1
      IF(IDIG.EQ.0) GO TO 553
      IPAD(4)= LAND(IPAD(4),MSK2(IDIG+1))
      ID= 80000;   CALL DELAY
      GO TO 551
553   IDIG = 3  ;  ID = 80000;   CALL DELAY
C
554   NS = 0
      CALL TSEL(IDEV,0,NS,IER)
555   IF(NS.EQ.0)GO TO 555
```

81

```
C
      NS = NS-NAC
      IF(NS.GT.10)GO TO 512
      IPAD(5)=LIOR(IPAD(5),LIOR(MSK(IDIG),LLS(NS-1,6*IDIG)))
      CALL TEXTO(IDEV,IPAD(4),2,29,18,2,3,IER)
      IDIG=IDIG-1
      IPAD(5)=LAND(IPAD(5),MSK2(IDIG+1))
      IF(IDIG.EQ.0)CALL TEXTO(IDEV,IPAD(4),2,29,18,2,3,IER);GO TO 512
      ID= 80000; CALL DELAY
      GO TO 554
C
C  FIELD = 3, NOS.,NORS,BEACH
540   IPAD(6) = IPAD(8) = 60606060B; IPAD(7)= 60545460B
      CALL TEXTO(IDEV,IPAD(6),3,29,34,2,3,IER)
      IW=6;MSK(1)=7777700B;MSK(2)=77770077B;MSK(3)=77007777B
      IPAD(6)=60006060B;IPAD(7)=60606060B
C
544   NS = 0
      CALL TSEL(IDEV,0, NS,IER)
541   IF(NS.EQ.0) GO TO 541
C
      NS = NAC
      IF(NS..EQ.13)IPAD(7)=4HNORS;IPAD(6)=4H    ; GO TO 542
      IF(NS..EQ.14)IPAD(7)=4HBEAC;IPAD(8)=4HH   ;IPAD(6)=4H  ;GO TO 542
      IF((NS.GE.1).AND.(NS.LE.10)) GO TO 543
      GO TO 512
542   CALL TEXTO (IDEV,IPAD(6),3,29,34,2,3,IER); GO TO 512
543   IF(IW.EQ.99)GO TO 545
      IPAD(IW)=LIOR(IPAD(IW),LLS(NS-1,ISH*6))
      CALL TEXTO(IDEV,IPAD(6),3,29,34,2,3,IER)
      ID= 80000; CALL DELAY      ISH = 3
      IF(ISH.EQ.0) IW= IW+1; GO TO 544
      IF(IW.EQ.8) IW= 99; GO TO 544
      IPAD(IW)=LAND(IPAD(IW),MSK(ISH))
      ISH=ISH-1
      GO TO 544
C
545   IPAD(8) = LIOR(00606060B,LLS(NS-1,18))
      CALL TEXTO(IDEV,IPAD(6),3,29,34,2,2,IER)
      ID=80000; CALL DELAY
      GO TO 512
C
C  FIELD = 4,  FUEL
530   MSK(1)=77777700B;MSK(2)=77770077B
```

82

```fortran
C        IPAD(9)=26006060B; ISH=2
C
         CALL TEXTO(IDEV,IPAD(9),1,29,58,2,3,IER)
532      NS=0
         CALL TSEL(IDEV,0,NS,IER)
531      IF(NS.EQ.0) GO TO 531
C
         NS=NS-NAC
         IF((NS.LT.1).OR.(NS.GT.10))GO TO 512
C
         IPAD(9)=LICR(IPAD(9),LLS(NS-1,6*ISH))
         CALL TEXTO(IDEV,IPAD(9),1,29,58,2,3,IER)
         ID=80000; CALL DELAY
         IF(ISH.EQ.0)GO TO 512
         IPAD(9)=LAND(MSK(ISH),IPAD(9))
         ISH=ISH-1
         GO TO 532
C
CCC
C        FIELD = 5,  REMARKS
520      IPAD(11)=60545460B
         CALL TEXTO(IDEV,IPAD(10),4,29,66,2,3,IER)
         ID = 80000; CALL DELAY
521      NS=0
         CALL TSEL(IDEV,0,NS,IER)
522      IF(NS.EQ.0)GO TO 522
C
         NS=NS-NAC
         IF(NS.EQ.21)GO TO 525
         IF((NS.LT.16).OR.(NS.GT.24))GO TO 525
C
         CALL TEXTO(IDEV,IFILL(IT(NS,1),IT(NS,2),29,66,2,2,IER)
         CALL TEXTI(IDEV,IPAD(10),IT(NS,2),0,NS+NAC,IER)
         ID=80000; CALL DELAY
         IF(NS.EQ.24)GO TO 523
         GC TO 512
523      NS=0
         CALL TSEL(IDEV,0,NS,IER)
524      IF(NS.EQ.0)GO TO 524
C
         NS=NS-NAC
         IF((NS.GE.1).AND.(NS.LE.10))GO TO 526
525      IPAD(10)=60545460B;IPAD(11)=IPAD(12)=IPAD(13)=60606060B
```

```
526     GC TO 527
        IPAD(12)=LIOR(60006060B,LLS(NS-1,12))
527     CALL TEXTO(IDEV,IPAD(10),3,29,66,2,2,IER)
        ID = 80000;  CALL DELAY
        GO TO 512
C
C  UPDATE STAT BRD         (TXT INT = 3 IF A/C DN)
C
517     IF(IPAD(3).EQ.4H DN )IPAD(14)=3;  IPAD(16)=1;  GO TO 516
        IPAD(14) = 2;  IPAD(16)=0
516     DC 518 I=1,16
        IF(IPAD(I).EQ.60545460B) IPAD(I) = 60606060B
        IDATA(I,JJ+IB) = IPAD(I)
518     CONTINUE
        IF(IDATA(6,JJ+IB).EQ.4H O )IDATA(6,JJ+IB)=4H
        CALL TEXTO(IDEV,IDATA(1,JJ+IB),13,(2*JJ-1), 1,2,IDATA(14,JJ+IB),M)
C
519     DC 515 J=1,5
        CALL TEXTO(IDEV,IBLNK(ROW(J)) ,WRDS(J),29,CPOS(J),2,3,IER)
515     CONTINUE
C
C  DIM 'CHANGE STATUS'
        CALL TEXTO(IDEV,IFILL(46),4,26,13,1,2,IER)
C
        RETURN
        END
        SUBROUTINE FLTDK(IDEV,IDATA,ACPAK,GDIR,TDIR,ITAC,IT2,IFILL2,SHIP,
       2 NN,IPLAN)
        INTEGER IDATA(16,20),TDIR(100),GCIR(31),GSAV(86),IT2(30,6)
        INTEGER IFILL2(55),ACPAK(86,20),SHIP(48),IPLAN(15,4)
        INTEGER ENDMOV(3)
        LNHC=LNAB=27;  IPOSHD =40;  IPOSAB=28
        GSAV(1)=IHEAD(0,0)
        DC 447 J=1,85
        GSAV(J+1)=IPACK(0.,0.,0)
447     CONTINUE
        CALL DTINIT(IDEV,TDIR,100,IER)
        IF(IER.NE.0)OUTPUT(101)IER;' 1'
        DO 449 J=1,ITAC
        ISQD=LRS(IDATA(2,J),18)
        IF((ISQD.EQ.4H0001).OR.(ISQD.EQ.4H0002))IWAC=64
        IF((ISQD.EQ.4H0003).OR.(ISQD.EQ.4H0004))IWAC=86
        IF(IDATA(1,J).EQ.4H F )GO TO 450
        IF(IDATA(1,J).EQ.4H H )GO TO 451
        IF(IDATA(1,J).EQ.4H A )GO TO 452
C
450     ACPAK(1,NS)=IHEAD(0,0)
```

84

```
      IF(IDATA(3,NS).EQ.4H DN )ACPAK(1,NS)=IHEAD(1,0)
      CALL GRAPHO(IDEV,ACPAK(1,J),IWAC,J,IER)
      IF(IER.NE.0)OUTPUT(101)IER, 2
      CALL UNPACK(ACPAK(2,J),ACX,ACY,III)
      IPOS=40-ACX+50
      ILN=20-ACY/.06
      CALL TEXTO(IDEV,IDATA(2,J),1,ILN+1,IPOS-2,1,3,IER)
      IF(IER.NE.0)OUTPUT(101)IER, 3
      GO TO 449
451   LNHD=LNHD+1
      IF(LNHD.EQ.41)LNHD=27;  IPOSHD=47
      CALL GRAPHO(IDEV,GSAV,IWAC,J,IER) .
      IF(IER.NE.0)OUTPUT(101)IER, 4
      CALL TEXTO(IDEV,IDATA(2,J),1,LNHD,IPOSHD ,1,3,IER)
      IF(IER.NE.0)OUTPUT(101)IER, 5
      GC TO 449
452   LNAB=LNAB+1
      IF(LNAB.EQ.41)LNAB=27;  IPOSAB=34
      CALL GRAPHO(IDEV,GSAV,IWAC,J,IER)
      CALL TEXTO(IDEV,IDATA(2,J),1,LNAB,IPOSAB,1,3,IER)
      IF(IER.NE.0)OUTPUT(101)IER
449   CONTINUE
      CALL GRAPHO(IDEV,SHIP,48,ITAC+1,IER)
      ENDMOV(1)=IHEAD(0,10)
      ENDMOV(2)=IPACK(-168,-079,0)
      ENDMOV(3) = IPACK(-239,-079,1)
      CALL GRAPHO(IDEV,ENDMOV,3,ITAC+2,IER)
      DO 103 J=1,25
      CALL TEXTO(IDEV,IFILL2(IT2(J,1),IT2(J,2),IT2(J,3),IT2(J,4),IFILL2,
     25),IT2(J,6),IER)
      IF(IER.NE.0)OUTPUT(101)IER
103   CONTINUE
      CALL IPLANT(IDEV,IPLAN,NN)
      RETURN
      END
      SUBROUTINE ADDAC(IDEV,ITAC,IDATA,ACPAK1,ACPAK2,GDIR,TDIR,IFILL2,
     2IT2,SHIP,NN,IPLAN,ACPAK1(64),ACPAK2(86),ACPAK(86,20)
      INTEGER IDATA(16,20),TDIR(100),IT2(30,6),IFILL2(55),SHIP(48)
      INTEGER GDIR(31),TDIR(100),IT2(30,6),IFILL2(55),SHIP(48)
      INTEGER IPLAN(15,4)
      CALL TEXTO(IDEV,IFILL2(24),3,22,50,1,3,IER)
      NS=0
      CALL TSEL(IDEV,0,NS,IER)
      IF(NS .EQ. 0)GO TO 440
      IF(NS.GT.ITAC)GO TO 439
      ISQD=LRS(IDATA(2,NS),18)
      IF(((ISQD.EQ.4H0001).OR.(ISQD.EQ.4H0002))GO TO 441
      IF((ISQD.EQ.4H0003).OR.(ISQD.EQ.4H0004))GO TO 442
      CALL GRAPHO(IDEV,ACPAK1(1),64,NS,IER);GO TO 443
439
440
441
```

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```
442       CALL GRAPHO(IDEV,ACPAK2(1),86,NS,IER)
443       IDATA(1,NS)=4H   F
          IF(IER.NE.0)OUTPUT(101)IER
          CALL MOVE(IDEV,NS,IER)
          CALL GRAPHI(IDEV,ACPAK(1,NS),NS,IER)
          CALL FLTDK(IDEV,IDATA,ACPAK,GDIR,TDIR,ITAC,IT2,IFILL2,SHIP,NN,
         2IPLAN)
          RETURN
          END
          SUBROUTINE ACMOVE(IDEV,NS,IDATA,ACPAK,GDIR,TDIR,ITAC,IT2,IFILL2,
         2SHIP,NN,IPLAN)
          INTEGER IDATA(16,20),ACPAK(86,20),GDIR(31),TDIR(100),IFILL2(55),
         2 SHIP(48),IPLAN(15,4),IT2(30,6)
          NT=NS-ITAC
          CALL TEXTO(IDEV,IFILL2(IT2(NT,1)),IT2(NT,2),IT2(NT,3),IT2(NT,4),1,
         2 3,IER)
C     SELECT AC TO BE MOVED
70        NS=0
73        CALL TSEL(IDEV,1,NS,IER)
71        IF(NS.EQ.0) GO TO 71
          IF(NS.EQ.ITAC+2)GO TO 72
          IF(NS.EQ.GT.ITAC)GO TO 73
          CALL MOVE(IDEV,NS,IER)
          CALL GRAPHI(IDEV,ACPAK(1,NS),NS,IER)
          IF(IER.NE.0)OUTPUT(101)IER;MOVE GRAPHI,
          CALL FLTDK(IDEV,IDATA,ACPAK,GDIR,TDIR,ITAC,IT2,IFILL2,SHIP,
         2 NN,IPLAN)
          GO TO 70
72        CALL TEXTO(IDEV,IFILL2(IT2(NT,1)),IT2(NT,2),IT2(NT,3),IT2(NT,4),1,
         2 2,IER)
          RETURN
          END
          SUBROUTINE UDGS(IDEV,IDATA,UP,DN,GO,GOCOL,SPARE,NN,NS,IPLAN,
         2 IFILL2,IT2,ITAC)
          INTEGER IDATA(16,20),UP(4),DN(4),GO,GOCOL,SPARE,IPLAN(15,4)
          INTEGER IFILL2(55),IT2(30,6)
          INTEGER ICOMP(3)
          DATA ICOMP/3*606060606B/
          CALL TEXTO(IDEV,ICOMP,3,39,76,1,1,IER)
          NT=NS-ITAC
C     BRIGHTEN SELECTION
          CALL TEXTO(IDEV,IFILL2(IT2(NT,1)),IT2(NT,2),IT2(NT,3),IT2(NT,4),1,
         2 3,IER)
368       IF((NN.EQ.4H*GO ).OR.(NN.EQ.4H*SPA)) GO TO 376
          IEL=0
          CALL TSEL(IDEV,0,IEL,IER)
369       IF(IEL.EQ.0)GO TO 369
          NT=IEL-ITAC
```

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      IF((NT.LT.14).OR.(NT.GT.17))GO TO 368
      CALL TEXTO(IDEV,IFILL2(IT2(NT,1)),IT2(NT,2),IT2(NT,3),IT2(NT,4),1,
     23,IER)
      IEL=IEL-ITAC-13
C
370   NS=0
      CALL TSEL(IDEV,0,NS,IER)
371   IF(NS.EQ.0)GO TO 371
      IF(NS.EQ.ITAC+21)GO TO 389
      IF(NS.GT.ITAC)GO TO 370
C
      IF(NN.EQ.4H*DOW)GO TO 372
      IPLAN(UP(IEL),IEL)=IDATA(2,NS)
      CALL IPLANT(IDEV,IPLAN,NN);KK=80000;CALL DELAY
      UP(IEL)=UP(IEL)+1
      GO TO 370
372   IPLAN(DN(IEL),IEL)=IDATA(2,NS)
      CALL IPLANT(IDEV,IPLAN,NN);KK=80000;CALL DELAY
      DN(IEL)=DN(IEL)+1
      GO TO 370
C
376   NS=0
377   CALL TSEL(IDEV,0,NS,IER)
      IF(NS.EQ.0)GO TO 377
      IF(NS.EQ.ITAC+21)GO TO 389
      IF(NS.GT.ITAC)GO TO 376
      IF(NN.EQ.4H*SPA)GO TO 379
      IPLAN(GO,GOCOL)=IDATA(2,NS)
      CALL IPLANT(IDEV,IPLAN,NN);KK=80000;CALL DELAY
      GO=GO+1
      IF(GO.EQ.16)GO=11;GOCOL=GOCOL+1
      GO TO 376
379   IPLAN(SPARE,4)=IDATA(2,NS)
      CALL IPLANT(IDEV,IPLAN,NN);KK=80000;CALL DELAY
      SPARE=SPARE+1
      GO TO 376
389   CALL TEXTO(IDEV,IFILL2(41),2,25,66,1,3,IER)
      KK=80000;CALL DELAY
      DO 390 J=13,21
390   CALL TEXTO(IDEV,IFILL2(IT2(J,1)),IT2(J,2),IT2(J,3),IT2(J,4),1,2,
     2IER)
390   CONTINUE
      RETURN
      END
      SUBROUTINE IPLANT(IDEV,IPLAN,NN)
      INTEGER IPLAN(15,4)
      ISLN=21
      ISPOS=77
```

87

```fortran
      DO 336 J=1,4
      DO 337 I=1,15
      IF(NN.EQ.4H*BLA)IPLAN(I,J)=0
      IF(IPLAN(I,J).EQ.0)GO TO 335
      CALL TEXTO(IDEV,IPLAN(I,J),1,ISLN,ISPOS,1,2,IER)
335   ISLN=ISLN+1
      IF((ISLN.EQ.26).OR.(ISLN.EQ.32))ISLN=ISLN+1
      IF(ISLN.EQ.38)ISLN=21;ISPOS=ISPOS+5
337   CONTINUE
336   CONTINUE
      RETURN
      END
      SUBROUTINE COMPLT(IDEV)
      INTEGER ICOM(3)
      DATA NMBR/0/
      NMBR=NMBR+1
      IF(NMBR.EQ.16)NMBR=1
      ENCODE(-12,901,ICOM)NMBR
901   FORMAT('COMPLETE',I4)
      CALL TEXTO(IDEV,ICOM,3,39,76,2,3,IER)
      KK=8000;CALL DELAY
      RETURN
      END
      SUBROUTINE BLANK(IDEV,NN,UP,DN,GO,GOCOL,SPARE,IDATA,ACPAK,GDIR,
     2 TDIR,IT2,IFILL2,SHIP,IPLAN)
      INTEGER ITAC,IT2,IFILL2,SHIP,IPLAN)
      INTEGER IDATA(16,20),TDIR(100),GDIR(31),IT2(30,6),IFILL2(55),SHIP(
     248),IPLAN(15,4),UP(4),DN(4)
      INTEGER ICOMP(3)
      DATA ICOMP/3*60606060B/
      CALL TEXTO(IDEV,IFILL2(48),2,31,58,2,3,IER)
      KK=16000;CALL DELAY
      NS=0
      CALL TSEL(IDEV,0,NS,IER)
      IF(NS.EQ.0)GO TO 90
C     CHECK IF BLANK WAS RE-SELECTED
      IF((NS-ITAC).NE.24)GO TO 92
C     BLANK OUT COMPLETE SIGNAL AT BOTTOM OF SPOT PLAN
      CALL TEXTO(IDEV,ICOMP,3,39,76,1,1,IER)
C
      CALL FLTDK(IDEV,IDATA,ACPAK,GDIR,TDIR,ITAC,IT2,IFILL2,SHIP,NN,
     2 IPLAN)
      DO 91 J=1,4
      UP(J)=1
      UP(J)=1;DN(J)=6
90    CONTINUE
91    GO=SPARE=11;GOCOL=1
92    CALL TEXTO(IDEV,IFILL2(48),2,31,58,1,2,IER)
```

```
      RETURN
      END
      SUBROUTINE ACINFO(IDEV,ITAC,IDATA,NS,IFILL2,IT2)
      INTEGER IDATA(16,20),IFILL2(55),IT2(30,6)
      NT=NS-ITAC
      CALL TEXTO(IDEV,IFILL2(IT2(NT,1)),IT2(NT,2),IT2(NT,3),IT2(NT,4),1,
     2 3,IER)
      NS=0
  444 CALL TSEL(IDEV,0,NS,IER)
      IF(NS.EQ.0)GO TO 445
      IF(NS.GT.ITAC)GO TO 444
      CALL TEXTO(IDEV,IDATA(2,NS),12,22,1,1,2,IER)
      CALL TEXTO(IDEV,IFILL2(IT2(NT,1)),IT2(NT,2),IT2(NT,3),IT2(NT,4),1,
     2 2,IER)
  445 RETURN
      END
      SUBROUTINE AHLIST(IDEV,NN,IDATA,ACPAK,GDIR,TDIR,ITAC,IT2,IFILL2,
     2 SHIP,IPLAN,NS)
      INTEGER IDATA(16,20),ACPAK(86,20),GDIR(31),TDIR(100),IT2(30,6),
     2 IFILL2(55),SHIP(48),IPLAN(15,4)
      NT=NS-ITAC
      CALL TEXTO(IDEV,IFILL2(IT2(NT,1)),IT2(NT,2),IT2(NT,3),IT2(NT,4),1,
     2 3,IER)
      NS=0
  310 CALL TSEL(IDEV,1,NS,IER)
      IF(NS.EQ.0)GO TO 311
      IF(NS.GT.ITAC)GO TO 310
      IF(NN.EQ.4HAIRB)IDATA(1,NS)=4H  A
      IF(NN.EQ.4HHANG)IDATA(1,NS)=4H  H
      CALL FLTDK(IDEV,IDATA,ACPAK,GDIR,TDIR,ITAC,IT2,IFILL2,SHIP,NN,
     2 IPLAN)
  311 RETURN
      END
      SUBROUTINE DELETE(IDEV,IFILL2,IPLAN)
      INTEGER IPLAN(15,4),IFILL2(55)
      INTEGER ICOMP(3)
      DATA ICOMP/3*6060606OB/
C BLANK OUT COMPLETE SIGNAL AT BOTTOM OF SPOT PLAN
      CALL TEXTO(IDEV,ICOMP,3,39,76,1,1,IER)
C
      CALL TEXTO(IDEV,IFILL2(43),2,27,64,1,3,IER)
      KK=5000;CALL DELAY
C PICK AC TO BE DELETED FROM SPOT PLAN
      NS=0
  330 CALL TSEL(IDEV,0,NS,IER)
      IF(NS.EQ.0)GO TO 330
C STORE AC NUMBER IN NNAC
      CALL TEXTI(IDEV,NNAC,1,0,NS,IER)
```

```
C    FIND AC NUMBER IN SPOT PLAN AND SET = TO BLANK
     DC 331 J=1,4
     DC 332 I=1,15
     IF(IPLAN(I,J).EQ.NNAC)IPLAN(I,J)=6060606OB
332  CONTINUE
331  CONTINUE
     CALL IPLANT(IDEV,IPLAN,NN)
     CALL TEXTO(IDEV,IFILL2(43),2,27,64,1,2,IER)
     RETURN
     END
META9300   PZE   LO,SI,GO
$MOVE      BRM   0,9SETUPN
           PZE   3
           PZE   0
IDEV       PZE   0
IBLK       PZE   Q
IER        LDA   Q*IDEV
           BRM   DVNOCK
           BRU   MDER
           STA   MCL+2
           LDA   FIOBFL
           STA   =060000000
           LDA   MSWO
           STA   *IBLK
           LDA   MSWO+2
           ECM   032004
$MCL       BRM   D>EXEC
$          PZE   2
           PZE   MSWO
           ECM   032001
           EOM   032002
           LDA   Q*IDEV
           SKA   IOBFL
           BRU   $-1
           LDA   $=0+2
MDER       LDA   $=1*IER
           STA   *IER
           BRR   MOVE
MSWC       PZE   0
           PZE   0
EOF        END
```

```
        META9300  LO,SI,GO
$TSEL   PZE       0,0
        BRM       9SETUPN
        PZE       4
        .PZE      0
        PZE       0
        PZE       0
IDEV    LDA       *IDEV
WHICH   BRM       DVNOCK
ISW     BRU       FNSDER+2
IER     STA       FNSCL+2
        STA       FIOBFL
        LDA       =050000000
        MRG       *WHICH
        STA       FNSSWO
        LDA       ISW
        ETR       =077777
        STA       FNSSWO+1
        ECM       032004

$FNSCL  BRM       D>EXEC
$
        PZE       2
        PZE       FNSSWO
        PZE       032001
        ECM       032002
        ECM       *IDEV
        LCA       IOBFL
        SKA       $-1
        BRU       =0+2
        LDA       =$+1
FNSDER  LDA       =*IER
FNSER   STA       TSEL
        BRR       00
FNSSWO  PZE       00
        PZE       00
        END

ECF
LOAD    XR,MAP
DATA
```

.617   .62   .608   1
.82   .58   .77   .6   1
1.52   .61   .86   .62 1
       .39   1.52   .59 1
                     .42 3
                     .18 7
                          9
                          5

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BEACH

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(TO GO TO NEXT PAGE, TOUCH ⌐NEXT PAGE⌐ BELOW
WITH THE LIGHTPEN)
INTERACTION IS ACHIEVED SOLELY BY USE OF
THE LIGHTPEN. TWO DISPLAYS ARE PRESENTLY
PROGRAMMED- THE FLIGHT DECK AND SQUADRON
STATUS BOARD DISPLAYS. THESE DISPLAYS MAY BE
SELECTED ALTERNATELY AT ANY TIME BY
TOUCHING THE LIGHTPEN TO EITHER ⌐FLT DK⌐
OR ⌐SQUAD STAT BRD⌐. MAKE ONE OF THESE SELECTIONS
NOW BY TOUCHING THE LIGHTPEN TO ONE OF
THE PHRASES BELOW.

95

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Present communication networks aboard aircraft carriers introduce inefficiency into the aircraft handling operation. A previous study, named CADOCS, failed to solve the problem by a method involving computer simulation. This study proposes a solution to the aircraft handling problem by use of a system of computer graphics terminals and interactive or "man-in-the-loop" programming. The study includes a proposed communication network, a discussion of the types of computer graphics hardware now

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(Page 1)   S/N 0102-014-6601 |

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available, a discussion of interactive programming, and a preliminary computer graphics program for two displays in the proposed system.